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Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies

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16. Abstract

The primary purpose of this report is to document helicopter involvement in disaster relief efforts and to gain an understanding of the general nature of such helicopter operations. A representative series of 18 case histories detailing disaster situations (i.e., airliner crashes, high rise fires, natural disasters, etc.) where helicopters have been involved in rescue and relief operations are studied in a case history format. Each case addresses to the greatest extent possible the circumstances of the disaster, the extent of rescue and relief efforts, the nature and extent of relief planning done prior to the incident in question, the nature of actual rotorcraft involvement, the number of people endangered in the situation, the number of people assisted through the application of rotorcraft, the success or non-success of the rotorcraft participation, analysis of the rotorcraft application, the types of landing areas used, and documentation of lessons learned and post-situation analyses. In the 18 case studies presented, rotorcraft transported approximately 3,357 people and contributed to the saving of approximately 187 lives.

Subsequent reports will: 1) analyze and document the strengths and weaknesses of the methods used in existing planning documents for the incorporation of rotorcraft into local disaster preparedness; 2) develop a set of guidelines for disaster preparedness agencies for use in the integration of local helicopter assests into the disaster planning process; and 3) produce a color video tape promoting the need for and the use of rotorcraft and heliports in disaster relief.

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PREFACE

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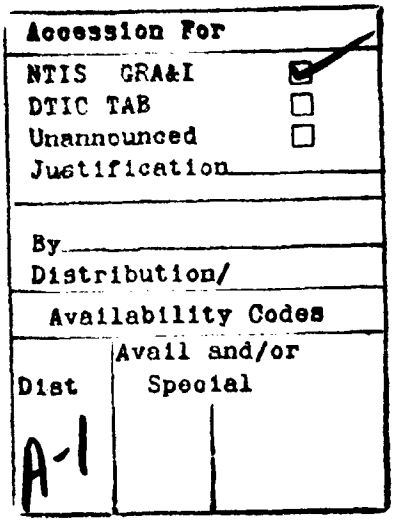

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1.0 INTRODUCTION

1.1 BACKGROUND

On Friday, January 13th, 1982, Air Florida Flight 90, a Boeing 737-222 with 74 passengers and 5 crew members on board, crashed in a blinding snowstorm on takeoff from Washington National Airport. It first struck the inbound 14th Street Bridge, congested with rush hour traffic, and then came down in the ice-covered Potomac River below. Only four passengers and one crew member survived the accident.

That even five people survived was due to the timely arrival of a U.S. Park Police helicopter. Despite a lack of proper on board rescue equipment, the helicopter was the key to extricating survivors and getting them safely to shore. The heroic efforts of the helicopter's crew, witnessed live on national television, provided dramatic proof of the helicopter's effectiveness as a disaster relief tool.

Disaster planning for the community is the responsibility of many public and government agencies at various levels. While the majority of those agencies are very proficient and effective in that effort, many of them are unaware of, or do not take full advantage of, the helicopter assets available to them in the local area. On the other hand, some communities, notably the Dallas/Fort Worth Metroplex, have successfully incorporated local rotary-wing aircraft into disaster preparedness plans and regularly hold realistic drills to test their effectiveness and to resolve problems under controlled conditions.

Because of the public's consistent exposure to "high technology", the exciting and romantic nature of aviation formerly held by the public has been replaced by a more sophisiticated and sometimes synical attitude. How and wny helicopters fly is still something of a mystery to many. This lack of public awareness, understanding, and the consequent lack of public acceptance has been a factor in preventing the helicopter's full integration into disaster planning.

Most civil helicopter operators are very willing to help out when needed, but they are often frustrated in doing so by a lack of coordination and communication with the local disaster planning agencies. It becomes obvious that the development of standardized planning guidelines and improved methodologies, by which rotorcraft assets can be incorporated into disaster planning, are needed.

1.2 PURPOSE

The primary purpose of this report is to highlight and document past helicopter involvement in disaster relief efforts and to gain an understanding of the general nature of such helicopter operations. A representative series of case histories detailing disaster situations (i.e., airliner crashes, high rise fires, natural disasters, etc.) where helicopters have been involved in rescue and other relief operations are presented.

This report is the first in a series of reports addressing the use of helicopters in disaster relief. Subsequent tasks will: 1) analyze and document the strengths and weaknesses of the methods used in existing planning documents for the incorporation of rotorcraft into local disaster preparedness; 2) develop a set of guidelines for disaster preparedness agencies for use in the integration of local helicopter assets into the disaster planning process; and 3) produce a color video tape promoting the need for and the use of rotorcraft and heliports in disaster relief.

1.3 TECHNICAL APPROACH

A representative set of disaster situations involving rotorcraft was assembled in chronological order (table 1). For each disaster situation on the list, a considerable amount of data was collected and analyzed, including official reports and post-situation analyses, newspaper accounts, photographs, and any visual media coverage. To the greatest extent possible, each case history addressed the following topics:

1) The nature of the disaster and the circumstances that brought it about;

2) the extent of rescue and relief efforts mounted to cope with the disaster, the organizations involved, and the number of people engaged in these efforts;

3) the nature and extent of relief planning that had been done prior to the disaster in question; the pre-accident plans, standard operating procedures (SOP's), protocols, mutual-aide agreements, and other documents prepared prior to the disaster; and the level of rotorcraft incorporation into those plans;

TABLE 1
CHRONOLOGICAL LIST OF CASE HISTORIES WITH
CONFIRMED ROTORCRAFT INVOLVEMENT

DATE	INCIDENT
February 1978	Northeast Blizzards Massachusetts, Connecticut, Rhode Island
November 1980	MGM Grand Hotel Fire Las Vegas, Nevada
February 1981	Hilton Hotel Fire Las Vegas, Nevada
June 1981	Tour Bus Crash Denali National Park, Alaska
January 1982	Air Florida Boeing 737 Crash Washington, District of Columbia
June 1984	Tornado Barneveld, Wisconsin
July 1984	Amtrak Derailment Williston, Vermont
July 1984	Mass Casualty Incident San Ysidro, California
January 1985	Molten Sulfur Spill Benicia, California
August 1985	Monocacy River Bus Crash Frederick County, Maryland
February 1986	Northern California Floods Guernville and Linda, California
December 1986	DuPont Plaza Hotel Fire San Juan, Puerto Rico
January 1987	Amtrak/Conrail Crash Chase, Maryland
October 1987	Military A-7D Crash into Ramada Inn Indianapolis, Indiana
May 1988	High Rise Fire Los Angeles, California
July 1989	United Airlines DC-10 Crash Sioux City, Iowa
September 1989	USAir Boeing 737 Crash LaGuardia, NY
October 1989	Earthquake San Francisco, California

4) the nature of actual rotorcraft involvement in rescue and other relief efforts associated with the situation; the number and type of rotorcraft on the scene and the crew compliment of each;

5) the number of people endangered in the disaster situation and (when appropriate) anecdotal accounts of their experiences;

6) the number of people who were saved or otherwise assisted through the application of rotorcraft in the disaster situation;

7) the extent to which the applications of rotorcraft in the disaster situation were successful and where they were not;

8) an analysis of why the rotorcraft applications were or were not successful in the disaster relief efforts associated with the situation;

9) the names, locations, and types of landing facilities (i.e.heliports - public, private, emergency, temporary, etc. - and airports) utilized in support of rotorcraft operations during the disaster situation relief efforts; and

10) documentation of the "lessons learned" and any other post-situation analyses regarding the use of rotorcraft in the disaster relief efforts associated with the situation.

Section 2 contains detailed descriptions of the disaster case histories, followed by discussions of the ten topics as they relate to the specific disaster under consideration. Section 3 contains conclusions and recommendations regarding the use of helicopters in disaster situations. The first part of section 3 summarizes the findings of the analysis of disasters. The last part of section 3 makes recommendations, based on the findings, for incoporating helicopter assets into the disaster planning process.

2.0 CASE HISTORIES

2.1 NORTHEAST BLIZZARDS OF FEB. 1978

> On Friday, February 3, the Eastern portion of the United States was dominated by a high-pressure system with generally fair winter weather. The only indication of a storm was a weak frontal system in the far West near the Canadian border. East Coast conditions changed little until late Saturday night when a weak low-pressure center began moving through the Great Lakes with typical, although significant, snow on the southern shores. The weak front from that low moved slowly through the Mid-Atlantic States during the day on Sunday, February 5. Snowfalls of several inches were recorded in the Appalachians, but it was not a particularly severe storm.[1]

Late Sunday, February 5,

> ...the low which was to create the blizzard was about 150 miles due south of Cape Hatteras. This was first noted by data received via satellite from a National Oceanic and Atmospheric Administration (NOAA) weather buoy near that area. The storm moved rapidly northeastward and was 180 miles due east of the Delaware/Maryland/Virginia Peninsula at noon on Monday, February 6. Major intensification occurred; winds increased to near hurricane velocity; and the storm center slowed and moved to within 75 miles of the New Jersey coast by 6 p.m. on Monday.
>
> For the next 24 hours the storm intensified and moved parallel to the Coasts of New Jersey, Long Island, NY, and Rhode Island. At 6 p.m., on Tuesday, February 7, it was about 75 miles due south of Nantucket. The speed increased rapidly, and the storm moved due east away from the coast Tuesday night and Wednesday morning.[2]

The Northeast Blizzard of '78 was one of the worst of the century. From February 5 to 7, it created havoc along the Eastern seaboard. In New York City, the 17.7-inch snowfall was the sixth largest since records began in 1869. Boston, MA, had over 2 feet, as did Providence, RI. Winds of over 55 miles per hour caused massive snowdrifts, drove seas through seawalls, undermined homes, destroyed beaches (including both Rockaway Beaches on Long Island), breached protective dunes, and left many areas from Cape May, NJ, northward open to further damage from spring coastal storms.

The American Red Cross reported 99 deaths and 4,587 injuries or illnesses attributable to the storm. More than 1,700 single-family dwellings were destroyed or suffered major damage. The Red Cross provided shelter for more than 39,000 persons stranded or forced from their homes by the storm.[3]

Table 2 shows the Red Cross Casualty and Loss Statistics.

The State of Massachusetts estimated losses from the storm at $500 million. Maine had an estimated $50 million loss, while total storm damage in New Hampshire was estimated at $14 million, including $1.5 million to highways. Property damage resulting from tidal flooding and beach erosion reportedly reached $44 million in New Jersey and over $40 million in New York. Total Federal assistance for the area affected by the storm, as reported by the Federal Disaster Assistance Administration, was $202 million.[4]

2.1.1 Impact of the Blizzard

A blizzard is the combination of a large amount of snowfall, high winds (35 mph or more) and low temperatures. The combination creates huge drifts, often as high as 15-20 feet. The Blizzard of '78 clearly met these criteria.

TABLE 2
CASUALTIES AND LOSSES AS REPORTED BY THE AMERICAN RED CROSS[5]

	MA	RI	NH	ME	NY	CT	PA	NJ	TOTAL
Deaths	73	26							99
Injured or illnesses	4,324	232	28	3					4,587
Hospitalized	483	50	1						534
Single Family dwellings:									
Destroyed	301		13	22				3	339
Major damage	1,057	15	170	200					1,442
Minor damage	4,995	15	170	300		20		150	5,650
Mobile home destroyed			1	1					2
Apartments or condominium units, minor damage	16		7	50	60			85	218
Small businesses, damage or destroyed	97		64	91				30	282
Total families reporting loss	6,466	15	425	664	60	20		208	7,858
Shelters operated	91	66	3		34	39	30	2	265
Persons sheltered	23,520	9,150	483		2,107	2,598	1,376	155	39,389
Victims and workers given mass care	50,930	52,317	560	20	5,350	1,819	1,500	500	112,996

Snow removal equipment and personnel were prepared for a significant snowfall and began plowing operations in the early stages of the storm. As the situation became worse, schools and government offices closed and many employers sent their employees home early. This action is very significant in a blizzard since having people go home and stay there can eliminate many potential problems.

As the storm intensified, the snow plowing crews were unable to keep pace with the

build-up of snow. The situation was particularly severe in the urban areas where snow had to be plowed and hauled away. The severity of the Blizzard of '78 simply overwhelmed efforts at snow removal by local public works departments and required the coordinated assistance of thousands of volunteers.

The greatest problem created by a blizzard is the loss of mobility. Critically needed personnel such as doctors and nurses were unable to travel to hospitals and nursing homes. The transportation system comes to a rapid halt when airports close, trains cannot run and buses and cars are immobilized. People are trapped in their stranded vehicles. For example, an estimated 1,500 vehicles were stranded in Rhode Island, over 3,000 were stranded in Massachusetts and several hundred were abandoned in Connecticut. However, the critical problem in the early stages is the thousands of vehicles and people trapped on the highways.

Storm conditions formed massive drifts on main roads and freeways. A series of collisions, trucks jack-knifing and cars stalling made travel by car literally impossible.[6]

2.1.2 Helicopter Involvement

With all the major road arteries blocked, side streets under several feet of snow, and limited transportation options, helicopters became one of the few means of transportation. Four-wheel drive vehicles, large snow plows, and snowmobiles quickly became the only vehicles which operated from Tuesday morning all the way through Friday. Ground transportation was used for the shorter haul situations while helicopters seemed to be used for longer trips (50 miles or more). All road travel, except for emergency vehicles, was banned in the states of Rhode Island, Massachusetts, and Connecticut.[7] Helicopters provided the means to move food and fuel and emergency medical patients to hospitals. As state emergency plans went into effect, medical helicopter ambulance companies were put on standby because many missions were expected as soon as the weather cleared.[8]

In Newport, Rhode Island, a young boy with rare blood diseases required inpatient blood platelet transfusions on a weekly basis.[9] When the storm hit, his father was stranded at his place of work in the city. The boy's mother was home and was worried about how they were going to get Michael to the hospital for treatment on Friday - 4 days away. Road transportation was impossible and the hospital where Michael required treatment was 60 miles away. On Friday, arrangements were made to pick up Michael, his mother, and a compatible blood donor (a family friend) in a National Guard Helicopter for transport to the hospital. The hospital visit was approximately 10 hours long and the National Guard airlifted the party back to Newport at the end of the treatment. There would have been no other means to get the boy to the hospital for his required medical treatment.

In Pawtucket, Rhode Island, a large parking lot adjacent to the Emergency Department at Memorial Hospital was cleared of snow and automobiles and used as a helipad.[10]

> Over the next four days, several landings of small and medium helicopters took place from it for various reasons. The major problem with the site was that people were used to parking there. It became necessary to leave a security guard on duty to prevent this.[11]

In an earlier winter storm, which had hit Indiana, Michigan, Ohio and New York, helicopter usage was also reported. A heavy snowstorm hit these states the last week in January of 1978. The governor's helicopter in Indiana, with the governor on board, transported a pregnant woman 60 miles from her small town to Lafayette, Indiana, on Friday, January 27.[12] "Two other people were rushed to Lafayette by a State Police helicopter that landed in a discount store parking lot."[13] In Scuth Bend, Indiana, helicopters transported patients from rural areas into the city.[14] In Lafayette,

> ...ambulances went as far as they could often reaching the destination. If they got stuck, snowplows tried to plow the way, 4-wheel drive trucks took over, or snowmobiles were used. Finally, helicopters were brought in if there was a place to land. But sometimes the runs still took hours.[15]

In Michigan, similar conditions were experienced. "In the cases where ambulances could not get through, the state police provided assistance with helicopters."[16] Once again helicopters were used to pick up two pregnant women, one with twins, at their homes for transport to the hospital.[17]

A 4 year old girl who had swallowed a straight pin was airlifted by the Ohio National Guard from her home to a nearby airport where an ambulance was waiting.[18] The pilot was directed to the vicinity of the child's home and told to look for a brightly colored blanket that had been spread on the snow to mark the exact location.[19] The Ohio National Guard also transported a woman, who was in active labor, by helicopter to the nearest hospital where she delivered a healthy baby boy.[20] A ground ambulance was unable to reach her through the impassable snowdrifts.

The blizzard created many extra problems for the emergency workers in New York also. "In one area a helicopter was reported being used to bring emergency monitoring equipment to a patient."[21]

2.1.3 Summary

Official reports state that both state National Guard and police helicopters flew missions in support of critical transportation requirements. The use of helicopters was limited because safe landing sites were unavailable. When ground transportation failed to get through, it was not always possible to rely on helicopters to take their place. Patients needing transport were those who required recurring inpatient hospital services, such as blood transfusions, kidney dialysis, and pregnant women in labor.

In summary, helicopters were extremely effective in transporting patients to hospitals. The characteristics common to situations where the use of helicopters proved most effective included: difficulty reaching the site by ground transportation, critical need for immediate transport, and the existence or temporary establishment of a designated landing site. Landing sites ranged from shopping center parking lots and hospital parking lots to airports and marked landing zones at the pickup site. Coordination for National Guard helicopter resources occurred at the state run emergency operations centers. The control procedures and practices of helicopter assets were undocumented.

2.2 MGM GRAND HOTEL FIRE, LAS VEGAS, NV, NOV. 1980

A fire at the MGM Grand Hotel on November 21, 1980, resulted in the deaths of 85 guests and hotel employees. About 600 others were injured and approximately 35 fire fighters sought medical attention during and after the fire.

The high-rise building, constructed in the early 1970's, consisted of twenty-one stories of guest rooms situated above a large ground-level complex comprised of a casino, showrooms, convention facilities, jai alai fronton, and mercantile complex. The hotel was partially sprinklered but major areas including the Main Casino and The Deli, the area of fire origin, were not sprinklered. About 3,400 registered guests were in the hotel at the time of the fire.

As reported by the Clark County Fire Department, the most probable cause of the fire was heat produced by an electrical ground-fault within a combustible concealed space in a waitresses serving station of The Deli.

Following full involvement of The Deli, a flame front moved through the Casino. Smoke spread to the high-rise tower through stairways, seismic joints, elevator hoistways and air handling systems. The means of egress from the high-rise tower was impaired due to smoke spread into stairways, exit passageways and through corridors.

The high-rise tower evacuation alarm system apparently did not sound and most guests in the high-rise were alerted to the fire when they heard or saw fire apparatus, saw or smelled smoke, or heard people yelling or knocking on doors. Many occupants were able to exit unassisted down stairs. Others were turned back by smoke and sought refuge in rooms. Many broke windows to signal rescuers or to get fresh air. The fire department

confined the fire to the Casino level in a little over one hour. It was approximately four hours before all guests were evacuated.

Of the 85 fatalities, 61 victims were located in the high-rise tower, and 18 were on the Casino level. Five victims were moved before their locations were documented. The 85th victim died weeks after the fire. Of the 61 victims found in the high-rise tower, 25 were located in rooms, 22 were in corridors, 9 in stairways and 5 were found in elevators. One person died when she jumped or fell from the high-rise tower.

The major factors that contributed to the loss of life that occurred as a result of this fire incident are the following:

- Rapid fire and smoke development on the Casino level due to available fuels, building arrangement, and the lack of adequate fire barriers.

- Lack of fire extinguishment in the incipient stage of fire.

- Unprotected vertical openings contributed to smoke spread to the high-rise tower.

- Substantial enclosure of interior stairs, smokeproof towers and exit passageways contributed to heat and smoke spread and impaired the means of egress from the high-rise tower.

- Distribution of smoke throughout the high-rise tower through the heating, ventilating and air conditioning equipment.

- Smoke spread through elevator hoistways to the high-rise tower.[22]

2.2.1 Impact of the Fire

> Some 600 persons injured as a result of the fire were treated, transported from the scene and ultimately seen by hospital personnel. Of the 600 injured, 318 were admitted to hospitals, and 282 were treated and evaluated in hospital emergency rooms and released later the same day.[23]

The National Fire Protection Association (NFPA) conducted a survey of 1960 of the 3400 registered guests in the hotel. Of those responding, 78.8 percent reported exiting the building by the stairs, 6.1 percent exited by the doors, and 5.8 percent reported exiting the building by helicopter."[24] The exact number of people evacuated by helicopter was not confirmed. However the NFPA estimated that 300 people were rescued by helicopter.[25]

> Fire damage other than smoke damage at the MGM Hotel was almost entirely limited to the Casino level and second floor office area. There was minor flame damage on one or two guest rooms on the fifth floor and heat and smoke damage on upper floors, but the major damage by fire was in the Main Casino, the lobby areas at the main and Flamingo Road entrances, the hotel registration area and the west end of the Hall of Fame.[26]

2.2.2 Helicopter Involvement

Helicopters were crucial to the evacuation of approximately 10 percent of the hotel's occupants. They were utilized in three primary roles: evacuation of hotel occupants, transporting rescue personnel and supplies, and providing aerial command and control to expedite operations.

Tom Mildren, a police officer with the Metro Police Department, was working routine patrol in Air #2, a Hughes 500, and was the first to spot the smoke and notify dispatch. He was also the first to arrive at the scene and to land on the roof. Officer Mildren recalls,

> It was a panic situation up there. At one time, there were about 200 people on the roof, and they all wanted to get on the helicopter at once. We were a long way from

> the fire, but these people didn't know that; they thought they were going to die if they didn't get into a helicopter immediately. So, I had to load the few who could fit inside, then fight back the rest, and let the helicopter take off without people hanging on. When we would try to get back onto the floor to evacuate more people, we had to try to clear enough space to land.
>
> When people are that panicked, they're not going to listen to logic; they're not going to calmly stand in line. Those people all wanted on, and they fought me like cats and dogs.[27]

Air #2 had to land with its tail rotor hanging off the roof when it made its first few landings on the roof because of the danger it posed to the panicked mass of people. The pilot of Air #2 solved part of the problem by dropping off the co-pilot on the roof to do site/crowd control. However, there was no ground support for the first few shuttle trips made. The people on board had to be left on their own to get off the aircraft. They did, many even before the aircraft touched down, and they were banging dangerously into the sides and undercarriage of the helicopter, some all too close to the tail rotor. People were dropped off in a dusty field near the hotel. Eventually ground control was established by the Metro Police Department and three more civilian helicopters arrived. At this point, Metro #2 stopped evacuating people from the roof and started performing local air traffic control for the rescue operation. As reported by the NFPA,

> Helicopter operations were jointly coordinated by McCarran International Airport Approach Control and the Metro Police Department. A Metro police sergeant at the command post maintained communications with the Metro helicopters. All of the on-site helicopter operations were coordinated by the Metro Police Department helicopter. Metro helicopters were in the air almost continuously, coordinating the operations of all other helicopters.[28]

A race track pattern was established, and with even more helicopters arriving, as fast as one helicopter would be loaded, another would land. According to one report, one helicopter hovered near the roof to blow away smoke while the others landed.[29] In approximately half an hour, the roof had been cleared. At any one time, there were 9-12 helicopters, a mix of civilian, commercial and military aircraft, in the air. Table 3 contains a list of the helicopter operators who responded to the scene. Air #2 kept them all informed of the location of other aircraft. One military pilot commented, "I don't think it would have gone any smoother if we had all sat together and had a 3-hour briefing and planned it as an exercise."[30]

By the time the helicopters had evacuated all the victims from the roof, the firemen also felt they had the blaze contained to the ground level. They began directing those guests who were able to walk down the stairways. More people would have been evacuated by helicopter if the fire department had not been able to contain the fire so quickly.

Approximately, three hundred people were airlifted from the roof representing seriously injured and smoke inhalation victims.[31] Helicopters brought in self-ccntained breathing apparatus (SCBA) bottles for use by the firefighters. Relief personnel were flown in to replace exhausted firemen. In addition, bodies were carried to the roof for removal by helicopter to a temporary morgue.[32]

As Air #2 circled the hotel after the rooftop evacuation was complete, it spotted many guests waving for help from their rooms. It used its public address system to tell them to stay in their rooms and remain calm.[33] It positioned the Air Force's CH-53's so that they could rescue people from balconies. They were equipped with hoists and penetrators (a device with seats that fold out like flower petals).[34] In order to move the sling close to the balconies, the CH-53 had to stay above the rooftop level to offset the diameter of the rotor. Even then, overhangs on each balcony prevented the slings from moving close. The rescuer would throw a cargo strap to the people on the balcony and they would pull him in by swinging him like a pendulum. Once on the balcony, he got out and strapped people in, one or two at a time, depending on their cooperation.

TABLE 3
HELICOPTER OPERATORS

1. Air #2, Las Vegas Metropolitan Police Department
   (first aircraft on the scene, two pilots)

2. "Flight for Life" from Valley Hospital, Las Vegas, NV
   (Second aircraft on the scene)

3. Silver State Helicopters, Las Vegas, NV
   (Third aircraft on the scene)

4. Action Helicopters, Las Vegas, NV
   (Fourth aircraft on the scene)

5. Bauer Helicopters
   (made several trips to Glendale and Overton, NV for air packs)

6. E.G. & G., Las Vegas, NV

7. Environmental Protection Agency, Las Vegas, NV

8. San Bernardino Sheriff's Office, San Bernardino, CA

9. Loma Linda University Medical Center, Loma Linda, CA

10. Air #1, Las Vegas Metropolitan Police Department
    (one pilot)

11. Nellis Air Force Base, Las Vegas, NV supplied nine helicopters: six UH-1N Hueys and three CH-53 Sea Kings, with an average of five persons per helicopter.

Colonel David Wallace was in charge of the three CH-53s. He recalls that,

> everyone who watched that particular operation admired the effort, but recognized the limitations of it. We're just not designed for massive evacuations, and it was a tedious, slow process; we couldn't take a large number of people because of that.
>
> It can also be argued that, hovering at that altitude, we caused more risk by being up there than the good that we were able to do. There was a lot of activity going on down on the ground, and if a rotor had hit the building and we had dropped the chopper down into those masses, we could have killed a lot more people than we actually saved. We can't argue with that, but at the time, it seemed like the smart action to take.[35]

The operation had to be suspended after only 15 (NFPA reported 12) people had been rescued; the draft created by the rotors was fanning the fire and disrupting the operations in one of the triage areas.[36] Supplies were being blown around and communications between rescuers required shouting.

As noted earlier, the last reported involvement of helicopters in the MGM Grand fire was in helping to evacuate the dead from the roof. The writer surmises that since most of the casualties occurred on or above the 20th floor of the 26 story structure, the firemen found it easier to carry the corpses up 1 to 6 stories rather than down 20 to 26 stories (elevators inoperative). According to one report,

> The helicopters flew for 3 hours in a nonstop, looping, counterclockwise circle; up from the parking lot to the roof, empty, and back down again with 3 bodies on stretchers. As the helicopters approached, their prop wash forced coroner's deputies to stand on the empty body bags to keep them from blowing away.[37]

In retrospect, the use of helicopters during the MGM Grand fire was controversial. Although helicopters rescued everyone who

made it to the roof, several people were believed to have died while trying to get there. It can be argued that seeing the helicopter evacuation in progress persuaded them to leave their rooms when safe passage was impossible and their best hope of survival was to stay in their rooms. Furthermore, there is the concern that in future high-rise fires, people with safe passage down stairwells may choose to go to the roof instead because of all the publicity received by the helicopter evacuation.[38]

Rescuers at the scene made the decision to quickly evacuate those they saw on the roof, because they had no way of knowing how serious the fire would become. As it turned out, roof occupants were never in serious danger.

> Shortly after the MGM Grand fire, the New York City Fire Department released a bulletin on its own policy regarding helicopter operations at high-rise fires, ...it can be anticipated that at future high-rise fires, more and more people will ignore fire department advice and will flee to the roof. It is recognized that roof evacuation by helicopter is an extremely hazardous and time-consuming operation and would be undertaken only as a last resort...[39]

Fire departments generally recommend that "down and out" is the best option for people to remember if trapped in a fire. Evacuees face two potentially dangerous situations: first, fleeing to the rooftop may take them into the fire and smoke rather than away from it; second, frightened or even panicked people may rush the helicopters without regard for their personal safety around the tail rotor. As experienced in the rooftop evacuation, when guests tried to grab onto skids or jam into the cabin, they may interfere with the control of the helicopter, imperiling not only their personal safety but that of the flight crew and people on the ground below. Finally, the need to properly load the helicopter jeopardizes an otherwise expeditious evacuation.

In other words, the decision to use helicopters for roof evacuation should be made by the fire department. The decision should be made based on the danger the occupants of the building are in. These issues were not generally known at the time of the MGM fire, but are considered today.

2.2.3 Summary

There were several important factors in the helicopter involvement at the MGM Grand Hotel fire. First, the weather was favorably calm and clear. Second, the fire occurred during daylight. And third, there were nine Air Force helicopters, three heavy lift helicopters (CH-53 Sea Kings) and six Hueys (UH-1N), on temporary duty at nearby Nellis Air Force Base available to augment the normal local helicopter population.[40]

All personnel involved in the helicopter operations agreed that they proceeded smoothly and safely. The only criticism of the operation came from those who questioned whether helicopters might have been over-utilized. Ironically, an effective helicopter disaster relief effort was rapidly developed without the benefit of extensive prior planning.

There was no, and still is no, disaster plan for the use of helicopters in Las Vegas. There are, however, some general guidelines that are followed by the various city departments. This includes coordination with air traffic control at the airport for airspace, set up and control of landing zones, and coordination with other commercial and civil helicopters. The idea is to maintain the flexibility to respond, or not respond, with helicopters as decided by trained emergency personnel knowledgeable in helicopter operations and knowledgeable in understanding requirements as to when helicopters would benefit the situation. In Las Vegas, if helicopters are to be involved, the Metropolitan (Metro) Police are responsible for them. They feel it would be impossible to write an effective standard operating procedure (SOP) to cover any situation. There is an emergency medical services (EMS) SOP for helicopters. However, this SOP deals mainly with single victim scenarios.

There were several lessons learned from the MGM Grand fire. None of the disaster drills had anticipated a multitude of helicopters, especially large helicopters, flying above the triage areas.[41] Future operations should consider the following:

1. Establish landing zones in grassy or paved areas to minimize flying debris from rotor downwash.

2. Shield microphones against rotor noise during transmission from ground based personnel.

3. Consider size of the helicopter in its application to the rescue problem. Large helicopters are generally more

disruptive due to the high rotor velocities, rotor downwash, and excessive noise. However, they may be the only suitable helicopter for certain operations such as the balcony rescues.

4. Communications are crucial to the effectiveness of the rescue operations. They include: air-to-air to accommodate helicopter intra communications into and out of the pickup and dropoff points; air-to-ground to position aircraft and advise when a landing zone (LZ) is ready for pickup or dropoff and to the command center for responding to additional mission requests.

5. For landing zone safety and support:
   a. a crash fire rescue (CFR) truck should be at the main LZ.
   b. a refueling area separate from the main activity of the LZ, but still within the watchful eye of the CFR truck. Refueling ferry time would be minimized and rescue efforts maximized.

2.3 HILTON HOTEL FIRE, LAS VEGAS, NV, FEB. 1981

At approximately 8:00 p.m. on Tuesday, February 10, 1981, eight people died and 350 were injured as a result of a fire at the largest hotel in the United States, the Las Vegas Hilton. This fire has a great deal of technical significance because of exterior, vertical fire spread that involved 22 floors of the 30-story building. This was the second multiple fatality fire in a Las Vegas hotel in a 2 1/2-month period; the first occurred November 21, 1980 at the MGM Grand Hotel and resulted in 85 deaths and 700 injuries.

The fire at the Las Vegas Hilton was incendiary in origin. The fire quickly developed in an elevator lobby on the floors above primarily by radiation. The fire progressed vertically from floor to floor to the top of the building via the building's exterior.[42]

At 8:05 p.m. on February 10, 1981 the dispatcher in the Hotel's Security Office

received a telephone call from an employee that there was a fire on the 8th floor in the vicinity of the East Tower elevator lobby.[43]

Security officers went to the 8th floor and verified the fire by portable radio.[44] The Clark County Fire Department was notified at 8:07 p.m., and upon arrival at the hotel moments later, saw that the fire had already extended to a third and fourth floor.[45]

2.3.1 Impact of the Fire

At some point after notification of the fire department, evacuation alarms were manually and automatically activated in the building although many occupants reported not hearing any alarms. It is likely that the alarm system in the East Tower failed early due to fire exposure. Voice communications capabilities were utilized by the fire department. Firefighters advised the occupants of their presence and what actions to take.

Occupants either evacuated via stairways, were trapped in their rooms by the fire, or waited the fire out in their rooms. Many people encountered smoke in the stairs, especially in the East Tower east interior stair. Some people in stairways were able to get to the roof where they were rescued by helicopters.[46]

There were no fatalities in rooms in which occupants kept the doors closed and waited out the fire for rescue. Partitions between the corridor and guest rooms along with the doors did resist the fire, even though some had severe fire exposure.[47]

A total of 23 engine companies, 6 ladders, 2 snorkels, 9 rescues, 2 air cascade units, and 12 aircraft were utilized during the fire fighting and rescue effort.[48]

2.3.2 Helicopter Involvement

> Less than three dozen people were lifted from the Hilton rooftop, with quick response by Dennis Mack of Action JetRanger helicopters, Silver State helicopters, Flight for Life, Bauer helicopters, and, of course, Las Vegas Metro helicopters. According to Dennis Mack, the Air Force Hueys were of help, blowing smoke clear of the stairwells.[49]

2.3.3 Summary

There was less of a need for helicopters in the Hilton Hotel fire than in the previous one at the MGM Grand Hotel. Fewer people needed emergency evacuation, because most of the evacuees were able to make their way down stairwells or simply stayed in their rooms. Fire crews directed people to stay in their rooms until they were told to evacuate. No heavy lift helicopters were involved in this incident because they were not on temporary duty at Nellis AFB at the time. The Air Force did respond with some Hueys, but they participated in support roles as opposed to direct victim evacuation. Once again, Metro Police took over the role of air command and directed the available helicopter assets to the roof for victim transport.

The Hilton Hotel Fire followed on the heels of the MGM Grand Hotel fire the previous November. Fewer people needed assistance at the Hilton and no one needed to be extracted from the sides of the building. Again, the same impromptu system worked well with the Metro police directing the other helicopters' activities. No mention was made in the available references concerning the effect of rotor downwash or impaired communications as was experienced in the MGM Grand Hotel fire. Since there were only 4 months to study the response to the MGM Grand Hotel fire and the onslaught of the Hilton Hotel fire, it is assumed that some of the same problems existed.

2.4 TOUR BUS CRASH, DENALI NATIONAL PARK, AK, JUN. 1981

> At 3:00 p.m. A.s.t., on June 15, 1981, a 40-passenger 1979 Bluebird Tour bus departed the Denali Park Hotel, Denali National Park, Alaska, with a student driver, instructor driver, and 30 passengers on board. The student driver drove about 65 miles to the Eielson Visitors Center while the instructor

driver offered driving suggestions to the driver and used the microphone of the public address system to "interpret" what the bus passengers were seeing along the route. The bus arrived at Eielson Visitors Center about 7:00 p.m. and departed about 7:50 p.m. for the return trip to the hotel. While returning, the student driver drove the bus and used the microphone headset to perform the narrative. The instructor sat on the floor in the stepwell near the door so he would not obstruct the view of the passengers.

Within a mile of the visitors center, the student driver stopped the bus to permit the passengers to watch and photograph several caribou that were at the right side of the roadway. After several minutes, according to the student driver, the bus started moving slowly forward so as not to startle the animals. The bus travelled approximately 1/2 mile before leaving the roadway. The student driver believed that the bus was in the center of the road, but realized he was over the road edge when he felt his right front wheel drop down the hillside. He estimated that the speed of the bus at this time was 10 to 15 mph. He tried to return the bus to the road by steering to the left but the wheel in the dirt would not move to the left but went farther right and the dropped lower as gravel scraped along the undercarriage of the bus. Witnesses later indicated that they were first aware of a problem as the bus was starting to tip to the right and stated that the right rear wheel dropped down as though the road had collapsed and the bus started to roll to the right. The bus rolled over slowly several times, some witnesses estimated as many as four to six times, but physical evidence indicated 2 1/4 times. The bus which had been traveling east came to rest 83 feet south of the roadway and about 35 feet below the elevation of the road.[50]

2.4.1 Impact of the Crash

> After the accident, the student driver stated he did not know what to do and was not useful at the scene. The instructor driver, however, started first aid action immediately after the accident and had started to organize the less injured passengers to aid the more seriously injured by the time another bus arrived about 5 minutes later. Other buses arrived shortly thereafter with medically trained people on board. Within 30 minutes, each injured person had at least one person rendering care, with one physician circulating among the injured on the ground and another physician checking those who had been carried to another bus.[51]

"Of the 32 occupants, 5 were killed and 26 were injured."[52] Two died at the scene, one died in surgery, and two other victims later succumbed to their injuries in the hospital.[53] Immediate medical treatment was provided by the visiting nurses, medics, and physicians on the tour. Additional medical assistance was provided by doctors and nurses arriving from other visitor center bus tour groups.

2.4.2 Helicopter Involvement

> When officials at Park Headquarters became aware of the accident, about 24 minutes after the accident, they alerted the military search and rescue units in the area and asked for assistance. Helicopters from the Elmendorf Air Force Base, 240 miles south of the accident site, and the Fort Wainwright Army Base, 95 miles northeast of the accident site, and a private airplane from the Park Headquarters, 60 miles east of the accident site, arrived at the scene over the next 2 hours following the accident. The aircraft transported the injured victims to the hospital in Fairbanks, Alaska.[54]

By the time the helicopters arrived all possible field treatment had been accomplished and the patients were ready for transport.

2.4.3 Summary

The National Transportation Safety Board (NTSB) report did not indicate how many patients were transported by helicopter versus ambulance to the hospital in Fairbanks. The location of the accident was remote as illustrated by having to call helicopter resources 95 to 240 miles away. Most of the lifesaving medical attention may already have been accomplished by willing visitors who happened to be nurses, emergency medical technicians, or physicians, as well as other medical helpers who coincidentally arrived at the accident site. They were able to stabilize and treat injuries and prepare the patients for transport. The helicopter's role was to bring in additional medical teams and transport the patients to the hospital.

2.5 AIR FLORIDA BOEING 737 CRASH, WASHINGTON, DC, JAN. 1982

> At 11:00 A.M. on Friday, January 13, 1982, the National Weather Service (NWS) in Washington issued a special weather statement that continued an earlier winter storm warning and predicted that snow would continue into the afternoon and, at times, become mixed with sleet and freezing rain.
>
> At 2:00 P.M., because of the deteriorating weather conditions, the Federal government agencies announced early dismissal of their employees, releasing some 400,000 commuters into the streets. Area schools also began dismissal early.
>
> At 3:00 P.M., the District of Columbia Department of Transportation was notified that an additional four inches of snow would fall. In the downtown area and on access roads, the traffic was slow and hazardous. A partial gridlock had developed downtown with traffic blocking some key intersections.
>
> At 3:59 P.M., Air Florida Flight 90, a Boeing 737 aircraft, carrying a total of 79 people, was cleared for takeoff by National Airport control tower. Taking off in a northwesterly direction over the Potomac, it immediately lost altitude, struck six vehicles on the inbound span of the 14th Street Bridge,

(about 20 feet from the Virginia shore), continued through the railing on the northwest side of the span, and crashed into the river, which was covered with five to eight inches of ice. The weather conditions were poor and deteriorating, temperature was in the low 20's and visibility was less than one-half mile.[55]

2.5.1 Impact of the Crash

At 4:04 P.M., CB operator Evelyn White received a number of broadcasts over her radio requesting help. These distress call were originating from bystanders on the bridge. She immediately dialed 911 and reported to an Arlington County (Virginia) dispatcher that a "...747 had crashed into the 14th Street Bridge." By 4:07 Arlington had dispatched three engine companies, two truck companies and two medic units to the Virginia end of the bridge. One minute later, FAA crash trucks arrived on the bridge and reported (to the control tower) they had found the crash site. They instructed the control tower to make a general area-wide announcement about the crash utilizing the Civil Defense alerting frequency, which is monitored by all jurisdictions and Federal agencies throughout the Washington metropolitan area.

The D.C. Fire Department, hearing the call from National Airport, dispatched four engine companies, three squads, two trucks, three basic life support units and two medic units to the Washington end of the 14th Street Bridge. By prior inter-jurisdictional agreement, the District of Columbia is ultimately in charge of any accident which occurs on the bridge or in the river. The County of Arlington would be responsible for any accident which occurs on that area of the Virginia shoreline.

Arlington's engine company and Medic 75 arrived on the scene at 4:15 P.M. What

> confronted both Arlington and FAA personnel was horrifying: at least half a dozen cars and trucks on the northbound span had their rooftops virtually crushed to seat level or sheared off completely.[56]
>
> Freezing victims clung to the tail section of the sinking jet liner while injured motorists clung to life, entombed in their crushed cars. Emergency medical teams who knew time is a critical element when dealing with hypothermia, were hampered and stalled by traffic jams caused by commuters who had left work early, homeward-bound in the thickening snowstorm.[57]
>
> For the six occupants who escaped from the aircraft, temperature, both water and air, was the major factor which affected their survivability. Water temperature four feet below the surface was 34 F. The survivors were in the icy water from 22 to 35 minutes before being rescued. Survival charts show that, based on the water temperature, at least 50 percent of the survivors should have lost consciousness during that time period. All five survivors reported that the cold was so intense that they quickly lost most of the effective use of their hands; however, none reported loss of consciousness.[58]

2.5.2 Helicopter Involvement

> At 4:11 P.M., the U.S. Park Police were notified of the accident and asked to send one of its med-evac helicopters to the scene to assist in rescuing the survivors, some of whom were now reported to be in the water.[59]

U.S. Park Police pilot Don Usher, and paramedic Gene Windsor, responded to the call from National Airport's tower. The policemen, on standby duty at U.S. Park Police Headquarters in Anacostia Park, Maryland, quickly grabbed life preservers and rope, boarded their Bell LongRanger, and took off. With a ceiling of 300 feet and one-half mile visibility, Usher flew Eagle I through the incessant snowstorm towards the 14th Street

Bridge by looking through the helicopter's "chin bubble" (the lower windscreen).[60]

> While en route, the crew of Eagle I, was given three separate locations for the accident site. However, they also headed for the bridge. By 4:13, airport officials informed Arlington dispatchers the plane was a 737 jet liner and that at that time the number of passengers and crew on board was unknown.
>
> Eagle I, with pilot Usher and crewman/ paramedic Windsor aboard, was now visible in the immediate area. Repeated attempts to reach any of the ground units by radio for instructions were unsuccessful. They were to learn much later that personnel on the ground had not switched to the correct frequency until 4:22 - two minutes too late to hear Eagle I. Early attempts with ropes and ladders to reach the survivors 50 - 100 feet offshore failed. Boats and divers were not yet on the scene.[61]
>
> "When you see an airline disaster you expect mayhem and slaughter." said Usher, during a later interview, "The biggest surprise was that there was only broken ice where, apparently, the main fuselage had gone through: the tail section above the water with six people hanging on it, and a lot of debris - insulation, luggage, handbags and clothes." The helicopter crew didn't know it yet, but there would only be those six to rescue. The others were doomed the moment the water rushed into their ruptured (airliner) cabin.
>
> The six had to be rescued quickly, however, before the frigid water claimed them. Usher and Windsor maneuvered dangerously close to the river surface the helicopter's skids could have iced up, destabilizing the aircraft and possibly causing Usher to lose control - and towed the survivors ashore with a lifeline. One woman, 22-year old Priscilla

> Tirado, lost her grip and was about to drown when an onlooker, Lenny Skutnik, 28, plunged into the river and brought her close enough to the bank for fireman John Leck to swim out and retrieve her. Later, doctors would measure Tirado's body temperature at 81 Fahrenheit; she was only several minutes from death by cardiac arrest.
>
> The rescue ended on a wrenching note: one of the six people clinging to the tail, a middle-aged man who was still unidentified by the weekend, had repeatedly passed the lifeline to fellow passengers rather than save himself. When the helicopter went back for him at last, he had slipped beneath the surface. "In a mass casualty you'll find people like him," said Windsor, "but I've never seen one man with so much commitment."[62]

2.5.3 Summary

Unlike other big cities, there was no written multiple casualty pre-plan available in the District of Columbia for EMS and hospital personnel to follow.[63] Further compounding this problem was the fact that municipal and Federal agencies, such as the U.S. Park Police, D.C. Police and Arlington Police, were using their own standard frequencies, none of which could be integrated with those being used by EMS or fire suppression officials.[64] As a result of the close scrutiny and analysis this accident received from various emergency response organizations, these problems have, for the most part, been resolved. They are only mentioned here to illustrate the effect they had, or may have had, on the use of helicopters in this particular situation.

Insofar as the use of helicopters in the relief operations associated with this disaster is concerned, there are several shortcomings to be discussed. (Fortunately, in the intervening time since the crash of Air Florida Flight 90, most of them have also been resolved.) Chief among them was a lack of any pre-plan for the use and coordination of local aviation assets for emergency response. Had there been such a plan in place, and, more importantly, had it been tested and evaluated through realistic drills, many of the difficulties met by Eagle I, with regard to communications, equipment, and training, would have become readily apparent and easily rectified.

On scene command and coordination of the helicopter(s) involved in the Air Florida disaster fell to the pilots actually flying the machines. Fortunately, the experience and professionalism of the men in those machines enabled them to carry out their missions safely and (more-or-less) efficiently in spite of the absence of any coordination plan. For example, although the Civil Defense Command Center had ordered five UH-1 Huey helicopters from nearby Fort Belvoir into the air, Don Usher's first radio report from Eagle I, upon arriving on the scene, confirmed the worst: between the two spans of the bridge and between the Potomac's narrow banks, there would be room for only one helicopter to maneuver.[65] Therefore, the other helicopters, which would have added to the confusion and the possibility of secondary accidents in the marginal weather (and would have been superfluous anyway), were spared exposure to that risk.

The National Transportation Safety Board, in their analysis and report on the overall accident, praised the job done by the Park Police helicopter crew and recognized the difficulties under which they had to work.

> The U.S. Park Police was notified of the accident at 1606. The U.S. Park Police helicopter did reach the scene promptly and although not equipped, nor required to be equipped, for water rescue operations, it predominated in the rescue effort. Eagle I, a jet-powered Bell Jet Ranger helicopter, arrived on the scene at 1622. The pilot hovered the craft near the survivors while his crewman dropped make-shift rescue aids - ropes with loops and life rings - to survivors in the water. The survivors were dragged to the shore in this manner. To accomplish one rescue, the crewman stood on the skid (bracing the rear passenger door open with his back) and pulled one of the survivors from the water. The Safety Board commends the heroic actions of the helicopter pilot and crew man who participated in the rescue effort.[66]

In the conclusions drawn by the National Transportation Safety Board in their exhaustive study and analysis of all aspects of the accident, the final point made was that the

"rescue of the survivors was due solely to the expeditious response of a U.S. Park Service helicopter, and the heroic actions of the helicopter crew..."[67] This assertion was supported by the post-accident comments of the Park Police helicopter crew themselves. They cited several reasons for the helicopter's vital role in the Air Florida rescue:

> First, a helicopter was the only vehicle that could hover and search for the victims, whose precise location was unknown immediately following the crash. In addition, the helicopter was virtually the only rescue vehicle able to quickly reach and rescue the survivors. It would have taken an ice-breaker several hours to plow its way through the frozen Potomac. Inflatable lifeboats were also inhibited by the ice floes. Even a fire department "air boat", capable of gliding over solid ice, was unable to maneuver through the fragmented ice surrounding the crash survivors.[68]

"With its ability to transport to area hospitals, the helicopter functioned as both a rescue vehicle and a med-evac aircraft as well," Windsor said.[69]

Several remedial actions have been taken in the Washington, D.C. area since the tragic occurrence of the Air Florida crash that would enhance any pre-accident, emergency or disaster response plan. Not the least of these was the development and adoption of The Greater Metropolitan Police and Fire Rescue Services Mutual Aid Operational Plan, which was signed on December 21, 1983. It is a product of the collective efforts of the Metropolitan Washington Council of Governments, the Washington Area Fire Departments, and an organization known as PACT (Police And Citizens Together). As part of this mutual aid agreement, a whole chapter on air response, and the command and control of local aviation assets, was included. It contains a clear explanation of the concept of operations and specifies the procedures to implement aircraft, primarily helicopters, in local disaster relief operations.

Other problems were brought to light in the rescue efforts connected with the Air Florida disaster. These mostly relate to onboard equipment and helicopter configuration, and, while not as fundamental as the need for planning, they are nevertheless compelling and should be addressed in any preparedness plan for

disaster response. For example, the FAA has purchased new rescue ("Billy Pugh") nets for use by helicopter crews in water operations in the Washington area. One net has been provided to the U.S. Park Police as special equipment for its helicopters.[70] Also, it has been decided to retrofit the Park Police helicopters with sliding rear passenger doors, to replace the standard swinging ones that hampered Paramedic Windsor's rescue efforts from the rear cabin of Eagle I.

The dramatic television news coverage of the rescue operations in the Air Florida tragedy, broadcast on national evening news, vividly projected the image of the helicopter as a lifesaver to millions of American viewers. The crucial role the helicopter can play in such situations has never been better demonstrated. That it can be better planned for, and therefore even more useful, was also well illustrated in the recommendations that stemmed from subsequent analysis of the events of the Air Florida accident.

2.6 TORNADO, BARNEVELD, WI, JUN. 1984

"Waves of thunderstorms pummeled the Plains and upper Midwest..."[71] early in the day on 7 June 1984 with more than 45 tornados. At least 16 persons were killed and hundreds were injured.[72]

> The storm system, which earlier dumped as much as a foot of snow in the Colorado Rockies, began spinning off tornados late Thursday and into the night from Kansas into Missouri, Iowa, North Dakota, Minnesota and Wisconsin. The storms also produced hail and heavy rain. Iowa reported 26 tornadoes, a record for one storm in that state. "In my 25 years here, I don't remember a storm that has been so widespread," said meteorologist Wayne Ellingson at the National Weather Service office in Des Moines. "I don't think there was any part of the state that was spared."[73]

As the storm continued into Wisconsin, a fierce tornado tore into Barneveld, Wisconsin. In 20 seconds, 90 percent of the town was destroyed by estimated winds of 250 to 300 miles per hour.[74] The tornado came without warning and there was no radar indication of its presence.[75] The National Weather Service had issued tornado watches to be in effect until 4 a.m..[76] "According to weather service officials, a total of five tornados occurred

with the first and most devastating one touching down in Barneveld in Iowa County at approximately 12:50 a.m. on June 8."[77]

2.6.1 Impact of the Tornado

The tornado struck with no warning and literally flattened Barneveld, a village of approximately 580 residents. It destroyed 120 homes, 11 businesses, the Village elementary school, 5 churches, and all the municipal buildings, including a new fire station and all equipment housed therein. The Village was left without electricity, telephone service and water. Many described the scene as similar to a war zone as it cut a swath approximately a quarter-mile wide and 13 miles long. In its wake the tornado left nine people dead, with over 60 persons requiring hospital treatment for injuries. It is estimated that countless others treated their own injuries and refused medical attention.

The amount and severity of disaster related damages are presented as follows for the two counties affected on June 8:

Private Damage	$12,569,000
Public Damage (State and/or Local Government)	880,890
Agricultural Loss (including farm dwellings, buildings, equipment, machinery, crops, cropland, and cattle)	8,000,000
TOTAL	$21,449,890[78]

Emergency medical services (EMS) units from Arena, Argyle, Avoca, Barneveld, Belmont, Blanchardville, Fitch-Rona, Iowa County, Madison, Mt. Hareb, and the University of Wisconsin Hospital responded to the disaster . Fire departments from Arena, Barneveld, Cobb, Darlington, Dodgeville, Hollandale, Mineral Point, Mt. Hareb, Ridgeway and Wiota responded. Most of the EMS and fire units were volunteer organizations. They performed triage and conducted search and rescue (SAR) operations. The disaster plans for Barneveld established the

municipal building, fire station, school and Lutheran church as relief and evacuation centers; however, the only building which was usable was the Township Garage.[79] All the other buildings in the town had been destroyed or damaged beyond use.

2.6.2 Helicopter Involvement

Few references to helicopters were found in the literature search. Wisconsin Magazine (video) mentioned that the 10th and final fatality of the Barneveld Tornado was a state trooper who was killed in a helicopter crash on his way to Barneveld. The Wisconsin National Guard had one helicopter assisting local authorities. In the video tape "Barneveld Lives", helicopters can be seen parked on the ground. This particular video footage appears to have been taken during the daylight hours of June 8th. Another reference was made in the "Barneveld Lives" videotape to helicopters: "...so many helicopters and small planes circled like vultures over the site that many disaster workers feared a mid-air collision." The helicopters in the area seemed to be more in a news gathering capacity then involved in relief operations.

2.6.3 Summary

Rescue operations were primarily ground intensive in nature. Helicopters performed surveillance missions for the news media and (presumably) rescue operations. The research notes their presence but does not describe their specific missions. Disaster plans had been developed, but were insufficient to deal with a disaster as destructive as the tornado.

Again, we are forced to consider weather conditions and helicopter operational requirements. If helicopters had been available, it is doubtful they would have been used before weather conditions were suitable or before daylight. With the destruction in town, it would likely have been unsafe to ask a helicopter to land, not knowing what conditions the LZ and obstacles around the town presented.

2.7 AMTRAK DERAILMENT, WILLISTON, VT, JUL. 1984

> On July 7, 1984, shortly before 7 a.m., a 12-car, two-engine Amtrak passenger train was traveling north through the western portion of Vermont between Williston and Essex Junction. At 6:51 a.m. the train hit a section of track crossing a run-off culvert

> which had been eroded away by the previous night's torrential rainfall. The first two cars and the two engines traveled across the flood-created ravine and four cars plunged into the two- to four-foot deep water and mud.[80]

"The last major train accident within the state occurred in 1887, so not surprisingly, none of the ambulance personnel had any prior experience with train rescue".[81] The weather in Vermont prior to the accident could be best described as wet and stormy. A storm front developed with colliding air masses of moist Gulf of Mexico air merging with a cold front advancing from the lower Great Lakes and Ohio Valley.[82] Numerous thunderstorm cells developed along the colliding bands and

> ...one such storm cell formed and intensified over the Adrirondack Mountains, crossed Lake Champlain, and struck the Vermont shore about 16 miles southwest of Essex Junction shortly after 6 p.m. Moving on a narrow northeasterly track, the center of the storm passed about 1 mile east of the accident site about 7 p.m. A second cell passed the accident site on about the same track between 9 and 10 p.m. Evidence indicates that a third intense storm cell moved on a parallel track 1/2 to 1 mile east of that followed by the earlier storms between midnight and 2 a.m., July 7.
>
> Each thunderstorm resulted in torrential downpours lasting up to an hour or more, and there were light, intermittent showers between these episodes of heavy rain. By 10:30 p.m., highway locations about 3.75 miles southwest, 3 miles northeast, and 7.5 miles northeast of the accident site were reported to be under water. A straight line connecting these locations passes 1 mile east of the accident site, and persons living at 10 locations on or near the line reported unofficial rainfall measurements of 5 to 7.25 inches overnight.[83]
>
> When the locomotive reached a point 200 to 250 feet east of the culvert, the fireman and

engineer saw a dark area in the track where they should have seen white ballast stone, and they realized the road bed under the track was gone. The fireman immediately applied the train brakes in emergency, but the remaining distance was not sufficient to materially reduce the trains's speed before the opening was reached. About 80 linear feet of the 20-foot-high embankment had washed out, but the track structure across the opening produced by the washout remained fully intact and taut. Both locomotive units and the first two cars crossed the track over the opening. According to the fireman, the locomotive dropped 3 or 4 feet and then bounced up as though it were on a spring board. The third car, a 30-compartment "slumbercoach", dropped into the opening and came to rest on its side more or less perpendicular to the embankment. Three passengers and an Amtrak attendant in the slumbercoach were killed. A food service car and a coach followed the slumbercoach into the opening, struck the slumbercoach, and came to rest on top of it. The rear eight cars stopped short of the opening and remained coupled and in line with the track. The first two cars derailed; the rear six cars did not.[84]

2.7.1 Impact of the Derailment

The conductor died about 3 hours after the accident bringing the total number of fatalities to five.[85] One train crew member, 2 Amtrak attendants, and 26 passengers were seriously injured.[86] All 294 persons on the train were processed through a triage system and 47 persons received outpatient medical treatment at a nearby IBM plant dispensary.[87]

Within a minute of the train crash, a call from a private citizen was made to the police who sent two officers to investigate. Rescue and Fire departments were put on alert for a possible train derailment. IBM emergency control workers heard the calls on their police scanner and 6 minutes later arrived on the scene to confirm the wreck.[88]

In one of several strokes of fortune that blessed the rescue effort, the two nearest hospitals - the Medical Center in Burlington and Fanny Allen Hospital in Winooski - were in the midst of shift changes as news of the accident came in. Those on night duty were still there, and the day shift was on its way in, doubling the available help. At the Medical Center, radio dispatcher Sean Leach had brought his own police scanner in as usual to "get a jump on things" should trouble occur. At 6:59 he heard some chatter over at Essex Junction about a train derailment. Normally, Leach is supposed to wait until someone asks him for assistance, but he knew Amtrak's schedule and feared the worst. By the time he was formally notified a minute later, Leach had already called out ambulances from Richmond and the University of Vermont.

Emergency Room Resident Steve Payne came into the radio room to listen. At 7:10 Leach began calling out heavy rescue fire trucks with special extraction equipment. Better to have too much equipment than too little, he thought. At 7:13 Essex Junction police reported five injuries, one serious. Leach dispatched Colchester Rescue. A minute later came a report that someone was pinned. At 7:16 Williston Fire Department reported multiple injuries and requested six ambulances. Two minutes later the Essex Junction dispatcher phoned with an electrifying message: "Send me everything you've got," she said frantically. "We've got dozens of injuries and three people are trapped and the train's on fire!"

At 7:15 Governor Richard Snelling, awakened at home by a call from the Essex Junction police, called Donald Edwards, the state adjutant general of the Vermont National Guard, and asked if he could assist the local authorities. Then Snelling rushed to the site to help organize the effort, staying throughout the day.

> For the National Guard it was perfect timing: a 2,400-man contingent was about to leave for maneuvers in Ft. Drum, New York. An hour later and they would have left. General Edwards ordered four helicopters, several medical and maintenance units totaling about 170 men, and a huge tank retriever to head on over. He hopped into a fifth 'copter and located a clearing near the wreck with barely 10 feet of blade clearance for the pilots who would fly out the more seriously injured.[89]

2.7.2 Helicopter Involvement

> Burlington has no rescue helicopter service. However, the governor mobilized the Vermont Air National Guard who supplied several helicopters and pilots. In retrospect, we were quite surprised to learn that use of these helicopters resulted in little or no reduction in transport time. This probably was due to the relatively short distance involved and the need to shuttle patients from the landing pad, half a mile away, to the emergency department by ambulance.[90]

The usefulness of the helicopters was hindered by two primary factors. First, the area of the train crash was heavily wooded and difficult to access by either land or air. As stated in the crash site accounting in section 2.7.1, the landing zone cleared for helicopter operations extended only 10 feet beyond the diameter of the rotor blades. Safe operations would require maximum performance takeoffs and might jeopardize the flight crew and passengers. Second, the trauma medical center was within a couple miles of the incident. State police effectively blocked off roads to allow only emergency vehicles. Ambulances were able to get from the ambulance staging area at the scene to the hospitals with great efficiency. Therefore, there was no advantage to using helicopters for patient transport.

Poor location of the hospital heliport proved to add to the helicopter's ineffectiveness. There was no helipad collocated with the hospital. It was a half mile away necessitating the transfer of patients from helicopter to ambulance to the

emergency room. A helipad at the hospital would have hastened the admittance of seriously injured patients to the trauma room.

The resources involved in the rescue effort are summarized in table 4.

2.7.3 Summary

> Since the accident, a special weather radio activated by the National Weather Service in Burlington has been installed in the dispatcher's office in St. Albans. The Vermont Central Railroad will never be caught off guard again.[91]
>
> In the Williston incident, teams from at least 16 rescue squads responded, including private and hospital-based ambulance services, as well as from the IBM plant nearby. Other responders included the National Guard, local and state police, fire departments, a construction company and Gov. Richard Snelling. Patients were transported to two hospitals, one of which (Vermont Medical Center Hospital) is a designated trauma center. In addition, the medical department at the IBM plant treated a large number of less-severely injured patients.[92]
>
> The success of the rescue efforts in Williston points to the need and value of disaster drills. For the ambulance and rescue squads in Vermont, the state is divided into 13 districts that coordinate disaster plans in that area. There have been at least two disaster drills a year since the early 1970's. Hospitals are also required to hold their own internal drills, twice a year. One of the hospitals involved, Fanny Allen, revised its disaster plans about 6 months before the incident to include other community agencies besides the ambulance corps. The result of the planning and practice was a rescue effort that saved lives. The National Transportation Safety Board investigates all major accidents involving transportation. When the Board's

TABLE 4
ACTIVITIES OF CONSTRUCTION COMPANIES
AND AGENCIES INVOLVED[93]

Construction

Accomplishments

2 Acres woodland converted to road
500 ft earthen dam built (8 ft high, 20 ft wide)
2,000 cubic yards fill moved
12-14,000 cubic yards cut and fill

Equipment

Cranes

125 ton link belt
65 ton P and H
20 ton P and H
20 ton Omega
15 ton Grove

Trucks and Other

24 dump trucks (with 74 on standby)
2 traxcavators
2 bucket loaders
3 tractor trailers
3 welding trucks
3 rigging and other trucks
4 bulldozers
1 backhoe
1 backloader

Lights

3 generators
12 scene illumination lights

Agencies Involved

17 ambulance rescue squads
2 first response squads
7 heavy rescue (extrication) squads
12 fire departments
3 police departments (2 local + state police)
6 construction companies
8 private restaurants and food stores
5 Air National Guard helicopters
American Red Cross
Civil Defense

> vice-chairperson described the rescue efforts as "amazing" and noted the "extraordinary" coordination, it was indeed a vindication for all the efforts-mostly by volunteers.[94]

Two favorable factors came together to support the relief effort. The Vermont Guard was on maneuvers a short distance away, just moments from deploying out of state for an exercise. The Guard didn't waste any time in assisting in the disaster. Command notification, governor permission, and control of the helicopter assets were all implemented very quickly. After the storm passed, the weather conditions improved dramatically so the helicopters were able to operate safely. The effort and results of helicopter participation were somewhat diminished, since they had to land away from the hospitals because of no collocated heliports. Patients had to be transferred from the helicopter at the helipad, to ambulance and finally, into the hospital.

Although helicopters were utilized in patient transport, their effectiveness was hindered by two critical deficiencies: lack of landing zones both at the scene and at the hospital.

2.8 MASS CASUALTY INCIDENT, SAN YSIDRO, CA, JUL. 1984

> It was shortly before 4 p.m. when James Oliver Huberty walked through the door of the McDonald's restaurant, just up the hill from his apartment. Wearing a black T-shirt, military camouflaged fatigues and a pair of sunglasses, Huberty brandished three guns: a 9-mm semiautomatic Uzi rifle, a 9-mm Browning semiautomatic pistol and a 12-gauge Winchester pump shotgun.[95]
>
> Without an apparent motive, Huberty, 41, husband, father of two daughters, unemployed security guard, mercilessly executed 21 people and wounded 19 more.[96]
>
> The gunfire was so heavy that police at first assumed that more than one gunman was inside. A fire truck took six shots before reversing direction and backing off. One firefighter was grazed by a spent bullet that tore through the truck and then landed softly on his head. Shortly after 5 p.m., as the

> gunfire slackened, one McDonald's employee crept up the basement stairs and out a back door, carrying crucial information to the San Diego police and the department's SWAT team: Huberty was alone, and he held no hostages. SWAT sharpshooters got their orders: "Fix him in your sights and take him out." The fifth shot by SWAT marksmen tore through Huberty's chest.[97]

2.8.1 Impact of the Incident

The first calls for help resulted from two different people walking into the San Ysidro Engine Company (fire department) and reporting bloody people and a gunman in McDonald's.[98] The San Diego City Fire Department Communications Division was notified, as well as the first paramedic ambulance from Hartson's Ambulance Service.[99] The fire engine responded to the scene and upon arrival was fired upon by the gunman. Shortly after that (10-15 seconds) an assistant manager of McDonald's who had been shot in the arm, burst through a restaurant window and ran to safety behind the fire engine. At this point the rescuers learned of 20 or more victims inside the restaurant. Police had arrived on the scene and dispatchers were informed of the increasing magnitude of the disaster. "Life Flight, the emergency medical helicopter of the University of Southern California, San Diego Medical Center, was summoned, and paramedics were called in."[100] A medical command post was established at a nearby shopping center, a dozen emergency units were on their way, local hospitals were notified of a disaster alert, and a second Life Flight helicopter was on its way.[101]

2.8.2 Helicopter Involvement

Upon notification that four victims required transport, one of two Life Flight helicopters was dispatched to the scene. Just prior to its arrival, a second helicopter was called out, bringing a flight surgeon and two additional nurses. The flight surgeon assumed command over the medical command post in anticipation of the intensive level of care that would be needed when the injured could be reached.

Initially, only one victim could be airlifted by helicopter, a woman found at the Post Office across the street from McDonald's. Television news helicopters arrived at the scene within 20 minutes and led to a false hope by victims in the restaurant that they would be rescued soon.[102] It wasn't for

another hour that the gunman would be downed, rescuers could begin triage and the victims could be transported.[103]

2.8.3 Summary

The murder of 21 people and the attempted murder of 19 more at the McDonald's in San Ysidro was a terrible tragedy resulting in a comparable number of deaths and injuries as might occur from a tornado. In the McDonald's incident, helicopters were requested by the fire department because of the initial estimate of four people in need of transport. Additionally, the congested street traffic of the afternoon rush hour impeded surface transport.

Fifteen people were treated and separated into two groups: the ambulatory and those critically injured requiring ambulance or helicopter transport to four neighboring hospitals. Many of the restaurant patrons were dead, greatly reducing the anticipated level of medical attention originally thought necessary. The injured all suffered from a common infliction - a bullet wound.[104]

Overall, helicopters are viewed favorably by San Diego area residents. The helicopters arrival signaled help and relief to those trapped in a life threatening situation.

2.9 MOLTEN SULFUR SPILL, BENICIA, CA, JAN. 1985

> About 11:50 a.m. PST, on January 19, 1985, a Cal Tank Lines tractor with two cargo tank semi-trailers, loaded with 54,730 pounds of molten sulfur, struck the center divider from the southbound lanes on the Benicia-Martinez Bridge (I-680). The two trailers climbed the barrier and landed in the northbound lanes of the bridge. One tank was completely destroyed and the other sustained several breaches. The molten sulfur spilled onto vehicles traveling in the northbound lanes and the highway surface where it ignited.[105]

2.9.1 Impact of the Crash

> The southbound tractor truck, with two double insulated tank trailers, each carrying 27,000 pounds of molten sulfur, collided with a passenger car, setting up a tragic chain of

events. The sulfur truck with double trailers hit the center divider wall, flipping the two trailer units over the center barrier. One unit immediately split open, spilling its entire contents. The second trailer landed on its side and ruptured in numerous places. The driver of the truck was pinned in the (now) upside-down tractor on the center barrier wall. The flying sulfur trailers, spilling their molten contents, came into contact with another tractor truck pulling an empty horse trailer, an El Camino pickup, and another passenger car (all northbound in the opposite lane.) The two occupants of the El Camino were seriously burned by spewing molten sulfur at 300 F splashing into the vehicle's interior.

At 11:52 a.m., an alarm was received (by the Benicia Fire Department) for a vehicle accident at the bridge toll plaza with fire and injuries. The communications center dispatched one engine and a paramedic unit. Two city police units were also dispatched to the scene. At the toll plaza, the police units immediately radioed information that was relayed to the incoming fire units as updates.[106]

Responding units experienced heavy traffic tie-ups getting to the scene and arrived at 11:59 a.m. Engine 1's Captain requested a second alarm immediately, two additional engines, more ambulances and (fire) chief officers. An excellent size-up was made and the captain went into the department's Incident Command System mode as the Interim Commander.[107]

California Highway Patrol (CHP) units arrived. In accordance with state law, the CHP has scene management responsibilities for incidents involving bridges, freeways and state highways. Acting as coordinators, they gave needed support and worked out long-range logistics. They did not take over the incident commander's role.

The paramedic unit rescued the most serious burn victim (who was burned over 58% of his body) with great difficulty, having to maneuver along a hill beside the road. Nevertheless, they were able to get the man into the paramedic vehicle. The burn victim was transferred to a private ambulance because (the Benicia Fire Department) wanted the paramedic vehicle, with its hydraulic rescue tool and air bags to remove the still-pinned (truck) driver on the center barrier.

One of the members of the paramedic crew, Firefighter Dave Botz, approached the overturned tractor and evaluated the situation. Botz, in full turnouts and Self Contained Breathing Apparatus (SCBA), returned to the paramedic vehicle to obtain a resuscitator.

As Botz returned to the overturned truck, he slipped in the molten sulfur and fell. The hot chemical saturated the rear of Botz's turnouts, igniting his coat and trousers and melting his boots. Botz was able to get up unaided and run out of the fire area. He jumped over the central barrier and removed his burning turnouts. ...Borrowing a pair of shoes from an onlooking fireman, he then put his SCBA back on and returned to the pinned victim without the protection of his turnout gear.

Using the protection of the center barrier, Botz tried unsuccessfully to pull the driver out, but the man's legs were pinned under the dash and debris. Tires were exploding and huge fireballs were erupting. Botz tried once more to free the victim and had to withdraw. The Benicia Fire Department was not able to rescue the man from the tractor. Fireman Botz was cited for a medal of valor for his heroic and unselfish efforts in attempting the rescue of the driver under most difficult extremes.[108]

The driver of the truck burned to death, still pinned in his cab. One of the two severely burned occupants of the El Camino pickup that was splashed with molten sulfur also died 4 days after the accident. The other serious burn victim, his wife, survived. Twenty-six other firemen, policemen, paramedics, toll takers and passersby received injuries of lesser degree, mostly smoke and chemical inhalation injuries and skin irritations. The tractor with the two double insulated tank trailers carrying the molten sulfur, the Mack tractor truck and its (empty) horse trailer, and three passenger vehicles and one tow trailer were completely destroyed in the accident.[109]

2.9.2 Helicopter Involvement

The official involvement of helicopters in this incident was minimal. One of the CHP units responding to the accident was "CHP Helicopter 32".[110] Its presence at the scene was the result of a request by the senior representative of the Highway Patrol to have a helicopter standing by for logistic and administrative support purposes. Because of low ceiling conditions throughout the time of response to the accident, CHP 32 was not used by the incident commander. There were, however, "four or five" electronic news gathering (ENG) helicopters constantly hovering and circling the scene during the initial phases of the rescue and fire fighting activities.[111]

2.9.3 Summary

While the extent of participation of helicopters in this disaster response situation was minimal, there are, nevertheless, several points to be examined in this case. First of all, it is the consensus of the responding paramedics that the use of helicopters to airlift the two burn victims to a trauma center probably would not have made any significant difference in the success of their treatment. One was burned so badly that he would have succumbed in any case. The other's injuries, while serious, were never life threatening and therefore did not require expeditious transport.[112]

As stated above, even though the California Highway Patrol helicopter (CHP 32) was on hand, it was not used. Helicopters did, however, have an impact on the response to the accident by the Benicia Fire Department. The ENG helicopters dispatched from several television stations in the San Francisco Bay area to cover the fire caused the on-scene incident commander some concern and difficulty. The sound of several helicopters

constantly overhead, operating at relatively low altitudes, added to the confusion and made it difficult for firemen to hear commands, even over personal radios. Also, there is always concern on the part of firefighters for the effect of helicopter rotor downwash on the "thermal balance" of a fire under attack, making an already uncertain and hazardous undertaking even more unpredictable. Furthermore, as part of the technique for dealing with hazardous materials (HAZMAT) situations, firefighters have developed a model for predicting the pattern and rate of dispersion of vapor clouds and toxic smoke from such fires. The model, based on the nature of the hazardous material in question, uses local winds and other meteorological conditions to determine the extent of danger to the local area. The unnatural influence of helicopter rotor downwash can disturb the airflow patterns and reduce the model's accuracy and effectiveness.[113]

On a positive note, partly as a result of this accident, the City of Benicia and Exxon, the operator of the refinery that produced the sulfur, have cooperated in the establishment of an emergency use helipad in the vicinity of the plant. It is on high ground near (but not too near) the refinery in order to facilitate evacuation of any casualties that may result from an accident at the facility. All local EMS helicopter services, as well as all city and county ambulance crews, are familiar with its location and use, and it is available for any contingency.

2.10 MONOCACY RIVER BUS CRASH, FREDERICK COUNTY, MD, AUG. 1985

> On the afternoon of August 25, 1985, a westbound inter-city bus with 17 occupants was traveling on Interstate 70, a four-lane divided highway near Frederick, Maryland. It was cloudy with light rain and the pavement was wet. About 12:40 p.m., as the bus descended a hill with a slight curve to the right, the rear tires of the bus lost traction. The bus moved side to side out of control, crossing both travel lanes and the right paved shoulder, and struck the left side of a reinforced concrete bridge (the Jug Bridge) over the Monocacy River before coming to rest.[114]
>
> ...the left front corner of the bus struck the left side bridge rail, creating a large opening in the front of the bus. It then rotated counterclockwise, overturned onto its

right side on the bridge pavement, and traveled westward another 267 feet before coming to rest (upright) against the left side bridge rail. The side windows of the bus were jarred open during the collision sequence. The driver and the left front passenger seated directly behind the driver were ejected from the bus and were thrown about 70 feet to the river embankment below. Twelve other passengers were ejected onto the bridge. No other vehicles were involved in the accident, and there was no fire.

Several motorists, who had witnessed the accident, stopped to assist injured passengers. Other motorists drove to a nearby residence and telephoned for assistance. An off-duty Maryland State Trooper, who was traveling westbound on I-70, arrived at the accident scene at 12:44 p.m. and radioed for assistance. The Frederick County Volunteer Fire Department received its first call about the accident at 12:46 p.m. Immediately after the call, a volunteer fire chief, who lived near the bridge and had been notified of the accident, arrived at the scene. At 12:48 p.m., the fire chief set up a command post and requested ambulance and medical assistance.[115]

2.10.1 Impact of the Crash

Approximately 77 persons, manning 13 ambulances, 5 rescue squad units, 2 special disaster units, 3 medic units, 3 fire engines, 3 helicopters, and 2 boats responded to the accident to provide emergency assistance. A triage was established and all injured persons were evacuated from the scene within 48 minutes after the arrival of the first rescue unit.[116]

One of the first fire/rescue team members to respond was Fire Chief Mark Fisher, a volunteer with United Steam Fire Engine Company 3 of Frederick. Because Fisher resides a short distance from Jug Bridge, his was the first fire service unit to arrive on the scene. Fisher left his vehicle to better size up the

situation, after making some useful and necessary reports by radio to other responding units. He observed a large gaping hole in the side of the bridge. He also saw obviously deceased and injured people lying in the roadway, and more injured people in the bus. The scene would be described later by fire and rescue personnel as being similar to a battlefield.[117]

Of the 17 occupants aboard the bus, 14, including the driver, had been thrown from the bus during the collision with the bridge guard rail. Four had been killed instantly; one other plus the bus driver subsequently died of injuries sustained in the accident; the rest of the passengers had (non-fatal) injuries ranging from minor to serious.[118] At 12:52 p.m., Chief Fisher requested helicopters.

2.10.2 Helicopter Involvement

At the time of the collision, the sky was cloudy, the temperature was about 70 F , and a light steady rain was falling. Based on available meteorology records, it was determined that at 12:40 p.m. on the day of the accident, the rainfall rate was about 0.06 inches an hour.[119]

> Three helicopters responded to the Jug Bridge incident: Med-Star 1 from Washington Hospital Center; Eagle I (U.S. Park Police) from Montgomery County (Maryland); and the Fairfax County Police helicopter. ...Due to the weather conditions, the closest helicopter, Maryland State Police Helicopter 3 (H-3) out of Frederick, was grounded. However, personnel from H-3 responded by vehicle to lend assistance.
>
> ...Early in the incident, Fisher had indicated that eight victims were candidates for airlift. But due to extremely poor visibility, the three helicopters reached the scene after all patients, except the bus driver, had been transported. Med-Star 1 and Eagle I were the first to respond. Initially, the (temporary) landing zone (LZ) selected was the westbound lane of I-70. Later, one helicopter was instructed to land at the Frederick Municipal Airport and the other at the Fort Detrick (Maryland) helipad. Weather conditions made it necessary for the

> helicopters to fly very low and to follow the highways to the accident scene. Neither Fort Detrick nor the airport was (operating in visual meteorological conditions.) Eventually, all three helicopters landed in the median strip of Interstate 70. Med-Star 1 transported the driver.[120]

2.10.3 Summary

The findings of the National Transportation Safety Board, in their highway accident report on this particular bus crash, concluded, among other things, that the emergency response was executed in a timely, orderly and efficient manner.[121] The helicopters involved in the accident were greatly hampered in their ability to significantly contribute to that successful response. Poor weather conditions, which were a factor in the cause of the accident itself, kept the closest medical emergency helicopter on the ground, unable to respond, and delayed the eventual arrival of other, more distant, helicopters to a point where they were too late to do much good.

If the disaster in question is either the result of, or directly related to, extreme weather conditions, helicopters may not always be capable of responding. Helicopter rescue should be an alternative to conventional means of transport in disaster plans. Consideration for helicopters should include: severity of injury/injuries; mission transport of injured, supplies, relief personnel; distance from medical centers; access surface congestion; and appropriate LZ's. In summary, rotorcraft can be a great asset in disaster relief operations. However, care should be taken so that they do not become part of the problem.

2.11 NORTHERN CALIFORNIA FLOODS, FEB. 1986

> The floods were the result of a series of severe storms that rolled in off the Pacific and pounded Northern California over a nine-day period beginning Feb. 12.[122]

The most severely affected areas from the storms were in Northern California along the Russian River in the Guernville area and below a broken levee in the Linda area.

2.11.1 Impact of the Floods

> When the flooding subsided, 15 deaths were counted and 33 counties were declared disaster areas. Officials estimated the damage at $375 million and reported at least 50,000 people were temporarily left homeless.[123]

2.11.2 Helicopter Involvement

> By Feb. 14, "I knew that we were going to be in for it," reported Sgt. Casey Howard, head of the Sonoma County Sheriff's Department (SCSD) aviation unit. "But nobody realized it was going to flood to the magnitude that it did."
>
> By Monday, Feb. 17, the Russian River was climbing canyon walls, endangering Guernville and the neighboring communities of Rio Nido, Hacienda, and Monte Rio - as well as other small communities, homes, and buildings scattered along its path down to the Pacific at Jenner. The California Office of Emergency Services, notified by SCSD of the emerging disaster, swung into action.[124]
>
> Spearheaded by California Air and Army National Guard aviation units, a miliary/civil cooperative helicopter effort spelled the difference between life and death for many trapped by floods... . Called out twice within a week in February, Guard helicopters, supplemented by those from public-service agencies and private operators, airlifted more than 2,400 flood victims in two closely coordinated rescue operations;... .[125]

Table 5 summarizes some of the known participants and the missions they flew in the relief efforts in the Guernville and Linda areas. The Sonoma County Airport served as the command post for the first joint California Air and Army National Guard Aviation operation.[126] Lt. Col Ted Schindler, mission commander, set up the command post, briefed the Air and Army Guard crews, established procedures, and arranged communications.[127]

TABLE 5
NORTHERN CALIFORNIA FLOOD HELICOPTER OPERATIONS
key: G = Guernville, L = Linda

Date	Area	Operator	Helicopter No	Helicopter Type	Mission
2/17	G	Helipad Aviation Inc.	1	MD500D	Sandbags to protect telephone switching equipment; airlift sick people when leaving stricken area
2/17	G	Calstar	1	BK-117	med-evac; lift Red Cross Supplies
2/17	G	Sonoma County Sheriff's Department (SD)	1	Bell-206B-3	med-evac; 1 water rescue
2/17	G	129th Aerospace and Rescue Recovery Group (Air Guard)	4 1	HH-3 HC-130, fixed wing	preparation for activity on Tuesday 2/18 at first light
2/17	G	126th Medical Company Army National Guard	3	UH-1	preparation for activity on Tuesday 2/18 at first light
2/17	G	40th Aviation Battalion (Army Guard)	3	CH-47A UH-1	preparation for activity on Tuesday 2/18 at first light
2/18	G	129th	1	HC-130, fixed wing	message relay; communications link for ground command post; refuel HH-3's
2/18	G	129th	UK	HH-3	pinpoint extractions; bring in medical supplies
2/18	G	40th	UK	CH-47's	evacuate 30 victims at a time from Emergency LZ's to airport; some sling operations
2/18	G	40th, 126th	UK	UH-1's	med-evac; utility flights
2/18	G	Helipad Aviation Inc.	1	MD500D	evacuate sick people; bring in supplies; evacuate telephone company employees
2/18	G	Sonoma County SD	1	Bell-206B-3	scout out LZ's for CH-47's
2/18	G	Aris Helicopter Ltd.	1	Astar	evacuate 30 PG&E employees
2/18	G	Sonoma County SD in another Jet Ranger	1	Bell-206B-3	damage assessment flights by emergency and government people
2/19	G	40th, 129th, 126th	UK	various	winding down of operations
2/20	L	California Department Forestry	1	UH-1F	evacuate stranded people off mall rooftop (RT), house RT, store RT, car RT
2/20	L	Sacramento County SD	1 1	MD500D Hughes 300C	command & control; rescues
2/20	L	CHP	1 1	Bell 206L-3 MD500D	evacuate stranded people

TABLE 5
NORTHERN CALIFORNIA FLOOD HELICOPTER OPERATIONS (continued)
key: G = Guernville, L = Linda

Date	Area	Operator	Helicopter No	Helicopter Type	Mission
2/20	L	41st Aerospace Rescue & Recovery Squadron (USAF)	UK 1	HH-53 HC-130, fixed wing	evacuations
2/20	L	49th Army Guard unit	2	CH-47	pick up commander (Schindler); airlift communications jeep; airlift 2nd jeep
2/20-2/21	L	126th	4	UH-1	evacuations
2/21	L	129th	2 1	HH-3 HC-130, fixed wing	evacuations, replace AF HC-130 fly Army Corp of Engineers survey team over levees
2/21	L	CHP	1	Bell-206B-3	med-evac
2/21	L	Sacramento County SD	UK	MD500D	rescues; support & survey for emergency personnel
2/22	L	495th, 126th, 129th	UK	various	final inspection flights

2.11.3 Summary

> Terrain and flooding made evacuation by helicopter a necessity. The trees, buildings, brush, butane tanks, and tons of other debris carried away by raging currents hampered or prevented rescue-boat operations along sections of the Russian River. At the same time the mountainous terrain, with its canyons and forested hillsides, made it extremely difficult to escape by land.[128]

Medical evacuations always had priority status. The Sikorsky HH-3's had a rescue hoist and two pararescuemen; they performed pinpoint extractions, emergency assistance, and some search and survey work. The Hueys(UH-1) with medics on board provided medical evacuations and some utility missions. The Chinooks

(CH-47A) performed shuttle missions, ferrying 30 people at a time to safety out of an LZ or operating with a sling to carry communication jeeps and other equipment. The police helicopters, working in pairs at night, assisted each other by one helicopter staying above the scene and providing illumination while the other helicopter went in and performed the extraction.

The success of the helicopter operations was due to a well coordinated command and control ground center which assigned most of the missions, ensured crew rest, and had excellent communications with all helicopters involved through the airborne Air Force or National Guard HC-130's. Approximately 2,400 people were evacuated due to these joint efforts.

2.12 DUPONT PLAZA HOTEL FIRE, SAN JUAN, PR, DEC. 1986

A mid-afternoon fire at the Dupont Plaza Hotel in San Juan, Puerto Rico, on December 31, 1986, resulted in 97 fatalities, including 17 employees, and 146 reported injuries. Nearly all the fatalities were located in the casino or in the hotel's main lobby area.

The fire occurred in a nonsprinklered, 20-story hotel complex which had two basement levels. The hotel contained the first-floor grand ballroom, a second-floor (main entrance level) casino, retail shops, restaurants, a registration area, and a function room. In the complex's high-rise tower were 17 guest room floors and a roof-top restaurant.

The complex included unprotected noncombustible and some combustible construction in the ballroom area; and fire-resistive construction in the casino, lobby area, and high-rise tower.

There were no fire detection systems within the complex; nor was there a fire evacuation plan for the hotel, an employee policy for reporting fire emergencies, nor any training of employees to complement such a plan. The local-only manual fire evacuation alarm system installed in the high-rise tower was reportedly not working at the time of the

fire. A standpipe and hose system in the high-rise tower also fed a partial automatic sprinkler system that protected areas remote from the fire and was not a factor in its outcome.

Local authorities, working with the Bureau of Alcohol, Tobacco and Firearms (ATF), determined that the fire was deliberately set using a single can of a "Sterno-type material" to ignite guest room furniture, still in shipping crates, stored in the unoccupied south ballroom. Once ignited, this abundant fuel load resulted in a rapidly developing fire that quickly ignited other combustibles within the south ballroom as well as the ballroom's combustible interior finish.

The fire was discovered in an advanced stage, beyond the control of some employees who attempted to suppress it. As word of the fire began to spread through the lower levels, flashover was reached in the south ballroom. Fire violently vented into an unenclosed stairway foyer area and began to spread products of combustion to the lobby/casino level. As the two-story-high foyer filled with heat and smoke, glass partitions in a masonry wall that adjoined the foyer and the casino soon failed. A smoke front, followed by a flame front, moved through the casino and lobby area and vented from the west wall to the exterior. For occupants still in the casino, there was little time between recognition of impending danger from the fire and its movement through that area. Some of the casino's occupants who acted early did escape, using one of the exits, during this time interval; some felt that they were in a smoke free area and closed exit doors to prevent infiltration; others broke exterior glass window walls and jumped to safety as the flame front was moving toward them.

Once the fire reached the lobby/casino level, products of combustion began to spread to the high-rise tower, trapping hundreds of unaware occupants. Rescue workers assisted many of the trapped occupants by directing them to the roof of the building, where they were removed by several helicopters making numerous return trips to complete their mission.

Even though significant amounts of smoke, heat, and toxic gases penetrated the high-rise tower, especially on its lower levels, there was only one fatality in the tower. It is felt that the exterior balconies provided occupants trapped for hours with a safe refuge area until the fire could be suppressed or they could be assisted by rescuers.

NFPA's analysis of the data points to six major factors contributing to the loss of life in the Dupont Plaza Hotel:

1. lack of automatic sprinklers in the south ballroom (room of fire origin).

2. rapid fire growth and spread.

3. lack of automatic fire detection systems/inadequate exit for the casino.

4. vertical opening between the ballroom and the casino levels.

5. smoke movement to the high-rise tower by way of vertical penetrations.

6. hotel tower occupants were not aware of a severe fire.[129]

2.12.1 Impact of the Fire

The enormity of the fire upon the fire department's arrival and the vast extent of the rescue effort completely outstripped the department's ability to alter the outcome of

> the fire or the amount of property damage. This is not an unusual circumstance in large, undivided, nonsprinklered, poorly protected buildings--especially when fire fighters are summoned for help after room flashover has occurred, as in this case.[130]

Although severe heat was able to penetrate the first 10 floors of the high-rise tower, there was no fire extension into the tower. All levels of the tower did show some evidence of smoke damage.[131]

The smoke drove people out onto the balconies where they formed groups by breaking down the glass partitions which separated them. The groups formulated strategies for survival. According to the NFPA, "Apparently these strategies were influenced by a group's location, knowledge of fire survival techniques, and rescuers including the helicopters hovering at roof level."[132]

> In spite of significant amounts of smoke that spread throughout the building and the high-rise tower, only a few fatalities can be linked directly to the effects of smoke. Nonetheless, the potential for a much greater number of fatalities existed; only a few fortunate circumstances, such as time of day and the balcony arrangement, prevented further deaths.[133]

There were 97 fatalities and 140 injuries in the fire. Eighty-four of the fatalities were in the casino, five fatalities were in the lobby, three were in an elevator between the basement and the first floor, one was in a guest room on the fourth floor (possibly asleep at the time), two were outside and two died from burns at local hospitals.[134]

Property damage estimates ranged between six and eight million dollars.[135]

2.12.2 Helicopter Involvement

Helicopter involvement in the Dupont Plaza Hotel fire was influenced by several factors. First, it was daylight. Second, there were 10 knot winds blowing and cross winds which made operations difficult.[136] Third, there was no helipad, nor a flat space large enough to land a helicopter on the roof. Fourth, the

fire had vented to the outside and was releasing heavy smoke and superheated, less dense air which interfered with helicopter operations.

There were six helicopters involved in the roof evacuation. Table 6 contains a list of the operators involved. The first helicopter on the scene was a Puerto Rico Police Department Hughes 500. However, the roof had a structure on top for machinery, and on top of the structure was a large sign and an antenna. The police pilot determined that he could not safely land on the roof. Approximately 45 minutes after the fire was reported, a Bell Jet Ranger piloted and owned by Mr. Walker of St. Thomas, Virgin Islands arrived. Mr. Walker had been alerted to the need for helicopters by air traffic controllers as he approached San Juan from the Virgin Islands. He quickly unloaded his charter customers and refueled the Jet Ranger before responding to the FAA's request. The FAA also contacted the USCG and the US Navy to request assistance at the same time; however, the Navy was 30 minutes flying time away and the USCG was 45 minutes away. All that was known and reported at that time by the FAA was that there was, "lots of smoke, lots of fire and lots of people on the roof."[137]

TABLE 6
HELICOPTER OPERATORS

1. Puerto Rico Police Department - Hughes 500 (first aircraft on the scene, one skid landings *)

2. Chartered Jet Ranger (second aircraft on the scene, one skid landings)

3. Puerto Rico Army National Guard - (provided local ATC)

4. US Navy - 2 CH-53 Sea Kings (hoist and basket)

5. USCG - Dauphin (2 pilots, 1 crewman, hoist and basket)

* One skid on roof, one skid in the air

Mr. Walker made the first landing on the roof of the Dupont Plaza Hotel.[138] He had to land with one skid off the roof and hold the aircraft in position while people boarded the aircraft. He reported being blinded at times by the smoke and heat. However, he rescued 21 people by his own count. After the police pilot observed the successful one skid landing, he joined in the evacuation. However, both pilots withdrew after the larger Navy helicopters (CH-53's) arrived.

The Puerto Rico Fire Department had also notified the USCG of the people trapped on the roof. Since the Navy base was 15 minutes closer to the scene, they were alerted by the USCG. Both services responded with large helicopters. The Navy arrived with two CH-53 Sea Kings and the USCG arrived with one Dauphin. Both types of aircraft were equipped with hoists and baskets.

The two Navy helicopters arrived shortly after Mr. Walker's Jet Ranger. They took over the evacuation with their hoist and basket system since it was a safer arrangement. Approximately 15 minutes after the Navy Sea Kings arrived, they were joined by the USCG Dauphin and a Puerto Rico National Guard helicopter. The Dauphin joined in the roof evacuation and the National Guard (NG) helicopter offered to perform local air traffic control.

The Dauphin was piloted by Lieutenant Commander R. Larsen. The following quote is from an article he wrote about the rescue:

> I really didn't know what to expect as I approached, but it was not the calmness and organization that we saw. On the roof were dozens of people, young and old, all in casual attire - people who had been forced out of their rooms by fire - calmly waiting to be rescued. There was no panic, no scramble for the helicopter. They were just standing or sitting next to the structure, as if they were waiting for the bus.
>
> There was a policeman on the roof who obviously was in charge. He should be put up for some kind of medal. He calmed the people and kept the crowd under control. When we came in, he must have pointed to the next four or five and said, "You, you, you, and you - you're next."

Our part was fairly easy. I was fortunate that day to have both a co-pilot and a crewman. We hoist people, or practice it, nearly every day. We have a basket about twice the size of a grocery shopping cart. A person sits in it and the crewman lifts it. The crewman, using a headset, guides the pilot so the basket is lowered right to the people. This operation takes practice and coordination, but Coast Guard and Navy helicopters do it routinely.

The vertical distance might be 20 or 30 feet and the hoist may last only a few seconds. But for someone who has never been in the air, 200 feet off the ground, the experience can be terrifying. In addition to the height, there is a lot of noise and wind. But I didn't see anyone who was not willing to go.

We loaded them, three, four or five at a time, and landed a short distance away on the beach. Lots of helping hands were there to care for survivors. None of our passengers was visibly injured, but these people must carry some emotional scars.

After unloading, we headed back to the roof. By now, the smoke was really swirling around, making it difficult to see and to fly. Occasionally, we flew into heated air and, being less dense, it couldn't support our weight. We would sink a little, then have to climb back up to where we wanted to be.

The civilian helicopter had found people trapped on the fifteenth or sixteenth floor, and the Army colonel asked us to try to rescue them. With a 200-foot hoist cable, it was possible to reach them. But, once in position, I could see people leaning out and reaching for the basket. I didn't want to see what would happen next: someone reaching just as we hit one of those hot air pockets and missing the basket. So we got on the PA

> system and told them to try to get to the roof, and we would take them from there.[139]

Unfortunately, every time a helicopter landed on the beach (75 feet north of the hotel) to drop off survivors the rotor wash fanned the flames and pushed the smoke toward the firefighters.[140] The noise from the helicopters overhead also made communications difficult. In some cases, firefighters were forced to talk face to face.

The Puerto Rico Fire Department tallied 215 persons airlifted to safety.[141] However, a lot of the roof evacuations took place after the fire was under control.

There was no emergency plan for the use of helicopters in existence during the Dupont Plaza Hotel fire disaster. In fact, the Puerto Rico Fire Department had never had a practice helicopter rescue of any kind.[142]

There is no mention in any of the literature about helicopters being used to transport firefighters or their equipment.

2.12.3 Summary

In contrast to other fire rescue operations reviewed in this document, the helicopter involvement was limited to retrieval of guests only. Six helicopters were involved, including civil, military, and commercial aircraft, all operating in a coordinated manner. Possibly one of the reasons that helicopters were not used more extensively is that preplanning and coordination for command and control responsibilities had not been accomplished.

The roof top evacuation was a success and is credited with rescuing approximately 215 people. However, the helicopter evacuation continued even after the firemen had the fire under control. Once it was clear that the people in the tower were in no immediate danger, perhaps the air evacuation should have been reduced or halted.

2.13 AMTRAK/CONRAIL CRASH, CHASE, MD, JAN. 1987

> About 1:16 p.m., eastern standard time, on January 4, 1987, northbound Conrail train ENS-121 departed Bay View yard at Baltimore, Maryland on track 1. The train consisted of three diesel-electric freight locomotive

units, all under power and manned by an engineer and a brakeman. Almost simultaneously, northbound Amtrak train 94 departed Pennsylvania Station in Baltimore. Train 94 consisted of two electric locomotive units, nine coaches, and three food service cars. In addition to an engineer, conductor, and three assistant conductors, there were seven Amtrak service employees and about 660 passengers on the train.

At this time, the Edgewood block station operator requested that switch 12 at Gunpow, a remote-controlled interlocking, be lined for straight through movement for train traffic on track 2, on which Amtrak train 94 was operating. The wayside signal aspects displayed for train 94 approaching Gunpow on track 2 were "clear" at both the distant (81-2) and home (2N) signal locations, and the wayside signal aspects displayed for train ENS-121 on track 1 was "approach" at distant signal 816-1 and "stop" at the home signal 1N. Automatic control systems in both trains should have displayed aspects corresponding to those of the wayside signals, except that the cab signals of train ENS-121 should have displayed a "restricting" aspect beginning 4,450 feet south of signal 1N.

About 1:30 p.m., Contrail train ENS-121 entered switch 12 onto track 2 causing the switch to realign for movement from track 1 to track 2. When train ENS-121 entered switch 12, the aspect of signal 2N for track 2 changed from "clear" to "stop". The engineer of train 94 apparently recognized that the aspect of signal 2N was "stop" and put his train into emergency braking. However, the train was traveling between 120 and 125 mph and could not be stopped before colliding with train ENS-121. The engineer and 15 passengers aboard train 94 were fatally injured; 174 other persons aboard the trains received minor to serious injuries. The rear Conrail locomotive unit, both Amtrak locomotive units, and the head three

passenger cars were destroyed. The middle Conrail locomotive unit was heavily damaged, and the rear nine cars of the passenger train sustained varying degrees of damage.[143]

2.13.1 Impact of the Crash

Amtrak Train 94. -- The forward cab in which the engineer was riding was crushed in the collision. Only the rear cab of the lead locomotive of train 94 was not demolished.

The unoccupied first car of the train was crushed. The car bodies of the second and third cars were severely crushed and deformed. The second car was on its side, and the third car was leaning. All of the fatally injured and most of the seriously injured passengers were in these two cars. Many passengers were pinned or otherwise trapped between dislodged seats, luggage, and structural members of the cars, yet some occupants were able to free themselves and leave the cars before rescuers arrived at the scene.

The rearmost nine cars were not heavily damaged. All remained upright with car bodies intact. Five of these cars were jackknifed, but no other car was bypassed and no car was struck in the side. The other four cars remained in line with the track. Most of the passengers in the rear nine cars were able to evacuate the train virtually without assistance. The four Amtrak trainmen and service personnel, who had received training in evacuation procedures, assisted the passengers in the other cars.[144]

2.13.2 Helicopter Involvement

Helicopters from the Maryland State Police (MSP) Aviation Division and Maryland Army Air National Guard were utilized to transport patients, supplies, and medical personnel and to fly utility missions such as photographic reconnaissance and traffic assessments. The

Maryland Army National Guard committed four Huey helicopters (designated A/C 781, A/C 752, A/C 134, and A/C 506) to the disaster. Because the weekend of the disaster was a drill weekend for the affected guardsmen, the ships were fully manned and flying in the area prior to the train collision. A/C 134 was returning to base when the pilot observed a smoke plume in the area of the crash site. Further investigation revealed the collision. The pilot then notified the Maryland State Police Aviation Division and other National Guard aircraft to respond. The four military aircraft transported a total of fifteen patients to various hospitals in the region and also flew various logistical missions such as photographic reconnaissance and personnel transport.

Since the military helicopters were not medically configured, it was necessary to utilize nurses from Franklin Square Hospital and medics from the Baltimore County Fire Department aboard the aircraft to provide patient care. Because of this, Priority 3 patients (those with minor injures) were flown on military aircraft and Priority 1 and 2 patients (more seriously injured) were flown aboard State Police Med-Evac helicopters. At 2:00 P.M. the Maryland State Police arranged through the Martin State Tower and FAA's Regional Flight Control Center to have the airspace around the crash site declared a temporary restricted zone for the aircraft not directly involved in rescue and Med-Evac operations. The air space restriction was assigned to the Maryland State Police for control purposes and was released at 8:00 P.M. on January 5, 1987. Enactment of this restriction significantly reduced the non-emergency air traffic in the area. A problem existed early into the incident because other aircraft (news media, etc.) were circling the area of the crash site while a significant number of Maryland State Police (MSP) and National Guard aircraft were performing emergency missions.

The military helicopters lacked the capability to communicate directly with components of the Maryland EMS system and the local fire departments on the scene. This presented a problem that needs resolution.

The Maryland State Police responded to the incident with a total of 7 aircraft (six Bell Jet Rangers and one Huey). A total of 12 patients were flown to various regional hospitals by the Maryland State Police aircraft. Throughout the day and evening of January 4 and 5, 1987, numerous utility missions such as photographic reconnaissance, medical personnel transport, supply transports, and traffic surveys were flown.

Initially, the helicopter landing zone was established on the south side of the Baltimore County Fire Station 54. However, as this area became more congested with responding aircraft and ground units, the State Police and MIEMSS jointly relocated the landing zone to the Oliver Beach Elementary School. This decision was in light of the inherent safety factors surrounding the landings at the fire station. Two engine companies from the Baltimore County Fire Department and personnel from MIEMSS Field Operations proceeded to the landing zone to provide fire safety and medical support. Cellular phones utilized by MIEMSS Field Operations personnel at the landing zone were extremely helpful in communicating to the crash site and with SYSCOM. Generally, the aeromedical operation proceeded well and only minor difficulty was experienced while supporting the EMS components and fire departments on the scene.

The Maryland State Police kept the Salisbury and Cumberland aviation sections in place to provide routine aeromedical coverage in the eastern and western ends of the state, respectively. The Centreville section was moved to Baltimore to provide coverage for

central Maryland and serve as an additional resource to the disaster site.

Throughout the course of the incident, the U.S. Park Police helicopters, U.S. Jet Aviation Corp. helicopters (a commercial carrier), and military aircraft from Tipton Field at Ft. Geo. G. Meade, MD, were placed on stand-by to fly med-evac missions in other parts of the state. Additionally, the White House telephoned SYSCOM to advise that the President's helicopter was available if needed. Fortunately, it was not necessary to utilize any stand-by aircraft.[145]

Army National Guard air traffic control equipment was emplaced and utilized. Army National Guard helicopters worked until 7:30 pm; the crews were debriefed until 9 pm; and one aircraft was placed on 5-minute notice after that.[146]

The improvised landing field was illuminated by Air National Guard light carts, 4-wheel drive vehicles fitted with gas-generated lights.[147]

2.13.3 Summary

Systems Communications (SYSCOM) is part of the state EMS agency (Maryland Institute for Emergency Medical Services Systems - MIEMSS) and coordinated Maryland State Police Med-Evac helicopter flights. A communications officer was sent to the helistop at the elementary school to communicate with SYSCOM via cellular phone. This cellular communication provided the essential link between the military helicopters and SYSCOM as the military helicopters operated on a different frequency than everyone else in the relief effort.

Total rescue personnel and apparatus on the scene consisted of over 220 pieces of equipment and 1000 rescue personnel.

The entire rescue operation ran smoothly, a real test of Baltimore's 5 month old disaster plan. Most of the responding agencies had worked together before during National Disaster Medical System (NDMS) drills. One of the lessons learned from the incident is communications with the National Guard

helicopters were lacking. The communications problem has not been fully resolved as of February 1990. The MIEMSS disaster plan has been modified to insert a communications operator with a cellular phone at the aeromedical staging area in future incidents. Since the Amtrak-Conrail incident, Maryland has not had a requirement to call upon the National Guard for additional helicopter resources.

The military helicopter's landing requirements were not clearly understood; some hospitals said they could not handle them because of the lack of landing space. Additionally, the temporary air traffic control post the military set up was used to control just military assets. Although both the MSP and the military were performing transport missions, there were times when their missions were not well coordinated. One reason for this was the lack of familiarity with each other's operations. Another reason was that although each entity operated independently to perform the same mission, they were unable to communicate with each other.

The crash site was in a remote stretch of track near the Gunpowder river bridge, adjacent to a small community with narrow, one-way streets, far from major roads. Police vehicles were left locked in the roadway, and gawkers and on-lookers congested roads before roadblocks could be set up. The contribution of helicopters for emergency transport of people and supplies became more valuable because of the congested surface roads.

Two areas need improvement as a result of the experiences gained in this incident. The first one is communications between military and civilian command posts or MSP helicopters must be established. The second area is when military helicopters are involved, their flight requirements must be known in advance so that landing zones can be properly evaluated and prepared. Agencies should agree on how landing zones are going to be controlled and ensure flight missions have an approved takeoff and landing assignment.

2.14 MILITARY A-7D CRASH INTO RAMADA INN, INDIANAPOLIS, IN, OCT. 1987

Ten people were killed and five others injured in Wayne Township, Indianapolis, Indiana, on October 20, 1987, after a pilotless military jet glanced off a bank,

> plunged into a Ramada Inn hotel and exploded.[148]

The jet had lost engine power while en route from Pittsburgh to Tinker AFB, Oklahoma, at 31,000 feet over Indiana.[149] Five minutes later the jet crashed after a powerless missed approach to the Indianapolis airport. One minute later rescue vehicles were on the scene fighting the fire at the Ramada Inn and starting their rescue efforts. The pilot had ejected after aiming his jet towards a large open field. CFR trucks from the airport fire station were on the scene immediately because they had been notified of the aircraft emergency by the tower. When the crash was confirmed by responding firemen, the airports disaster plan was put into effect.[150]

2.14.1 Impact of the Crash

> The pilotless jet clipped a one-story bank building, tearing off two-thirds of its roof. None of the six employees or three customers inside the bank were injured. The plane then skidded across a street, hit a ravine, bounced into the air and smacked, belly-first, into the carport in front of the seven-story Ramada Inn. The pilot landed by parachute approximately one block from the hotel.[151]

Nine people who were employees of the hotel were killed. The tenth victim died of burns several days after the crash.[152] As many as 170 people were estimated to be in the hotel at the time of the crash.[153] First and second alarms were sounded and all EMS personnel in the county were put on standby alert.[154] "Overall, there were 45 agencies involved in the resolution of this incident: 21 local, 7 State, 3 Federal, and 14 private companies."[155] The Marion County Emergency Management Plan was activated at a level one status alerting all fire, police, medical and public officials.

2.14.2 Helicopter Involvement

> Methodist Hospital's LIFELINE helicopter responded with a physician Triage Coordinator, landing at 0949 hrs. A surgeon requested by the coordinator arrived on-site at approximately 1020 hours.[156]

A helispot was located immediately east of the Command Area by the Treatment Area, used by the LIFELINE helicopter. Air support from the Indiana National Guard to DOD Investigators used their helibase at Stout Field, several miles to the east-northeast.[157]

Three Air National Guard (ARNG) helicopters were requested from the ARNG Aviation Center in Shelbyville, Indiana to fly to Stout Field, standing by there for instructions on any rescue missions. At the request of US Army CID personnel, an ARNG helicopter was used for photographically recording the incident (continuous video, and still photography, until the fire was extinguished).[158]

2.14.3 Summary

Three victims from the Ramada Inn, the pilot, and two fire fighters were transported to area trauma and burn centers from the incident, using ground ambulances that proceeded along the emergency traffic route which had been established to these downtown hospitals.[159]

Although tragic, the crash of the A-7D into the hotel could have caused a more horrific situation than what resulted. A conference room was scheduled a little later for 70 guests; many guests of the hotel had already checked out; and the lobby contained only 1 non-employee at the time of the crash. CFR personnel were on the scene in seconds and put out the major portion of the fire within minutes. The participation of helicopters in rescue and relief efforts was small, but the resources were available for their support, i.e. a helistop had been established. Communication with the ARNG was excellent and they had the capability for victim transport if necessary.

2.15 HIGH RISE FIRE, LOS ANGELES, CA, MAY 1988

A major after business hours, high-rise office building fire occurred on Wednesday, May 4, 1988 in the city of Los Angeles, California, resulting in one fatality and

ultimately destroying four floors of the First Interstate Bank Building.[160]

Constructed during the early 1970's and first occupied in 1973, the building is Los Angeles' tallest high-rise building. When built, the 62-story structure was intended to anchor the skyline for the city's emerging financial district on the south end of downtown.

The building is the corporate headquarters for First Interstate Bank, employing 1500 bank employees at this location. In addition, the building contains leased office space for additional tenants, including law offices and other banking and financial institutions. On a typical business day approximately 3500 people occupy the building. In addition to office occupancy areas, the building contains an employee cafeteria, sub-grade parking areas, a public banking area located on the street level, and a rooftop heliport.[161]

The Los Angeles City Fire Department described the suppression effort as the most challenging and difficult high-rise fire in the city's history. It took a total of 64 fire companies and 383 firefighters more than 3 1/2 hours to control the fire.[162]

At the time of the fire, there were only about 40 occupants in the building. They included bank employees who were working late, building security and maintenance personnel, a cleaning crew, and workers installing an automatic sprinkler system in the building. Although the building was in the process of being retrofitted with automatic sprinklers, the system was not complete and was not operational at the time of the fire.

2.15.1 Impact of the Fire

One fatality resulted from the fire - a maintenance worker who had taken an elevator to the 12th floor to investigate the cause of the fire alarms. Others were able to evacuate via stairways; eight were lifted off the roof by helicopter. Fire damage was extensive from the 12th to 21st floors. It was estimated to take 30 - 60 days before the floors below 22 could be occupied due to a combination of fire and water damage.[163]

2.15.2 Helicopter Involvement

"At approximately 10:35 p.m., Los Angeles City Police Department helicopters AIR 8 and AIR 3 observed a major fire in progress..." at the bank building. Between the two helicopters, they rescued six maintenance persons from the roof.[164] A fire department Bell 206 command ship and a Bell 205 were soon on the scene. The 206 searched the building floor by floor, illuminating the scene with its Nightsun searchlight.[165] The 205 dropped a paramedic team off on the roof to search for more victims. Two other fire department helicopters arrived on the scene and transported more fire crews and support equipment to the roof. The first 205 on the scene stayed on the roof, idling in the event a quick escape by the rescue teams was necessary. Meanwhile, the fire department's EMS-equipped Bell 412 was standing by at the scene. The searching 206 spotted a man trapped on the 50th floor and the 412 was used to med-evac him from the roof.

In all, fire department helicopters logged 26.9 hours on the scene and the police helicopters logged 2.6 hours. A total of four fire department and two police helicopters were involved.

2.15.3 Summary

Several observations and recommendations were determined by the Los Angeles City Fire Department in relation to air operations. They are as follows:

> Air Operations and the Medical Group should report directly to the Incident Commander. The information provided by these two support groups is of more use to the Incident Commander than to Operations. In addition, if Operations moves inside the building, as was the case in the First Interstate fire, it becomes very difficult for him to communicate

with or supervise Air Operations or the Medical Group.[166]

Air Operations and the Medical Group should be on separate radio channels so as not to interfere with fire ground and fire command radio communications.[167]

Air Operations should not be prematurely demobilized. At the First Interstate fire, a complete search of all floors above the fire was conducted after knockdown at 0219 hours. Air Operations should have continued in operation and transported fresh search and rescue teams to the roof.[168]

Helicopters should not fly closer than 250 feet to a high-rise building fire floor. The experience gained at First Interstate indicates that the noise and turbulence created by helicopters had a negative effect on fire fighting operations, staging, and fire ground communications.[169]

Helicopters were pivotal in identifying victim locations along the windows of the building. They were able to search, spotlight, and hover along all sides of the building while looking for victims of the fire. Their participation was particularly important because of the buildings height and because it was night. It would have been difficult or impossible to spot victims from other buildings or from the ground in night time conditions. The helicopters contributed in many other roles during this fire and the night search capability was particularly prominent in this incident.

2.16 UNITED AIRLINES DC-10 CRASH, SIOUX CITY, IA, JUL. 1989

United Airlines Flight 232, bound for Chicago from Denver on July 19,1989, suffered an explosion of the tail-mounted engine fan assembly just after 3:00 p.m. This occurred approximately one hour into the flight at an altitude of 37,000 feet. Parts of this engine were thrown outside the cowling and penetrated the right horizontal stabilizer where lines to all three hydraulic systems for control of the plane are located. After

the loss of the engine, the plane immediately descended and banked right. The flight crew soon discovered that they had lost function of all three hydraulic systems and could only make right turns and control the plane by using the throttles. An emergency was declared by the captain, and emergency procedures begun. It was soon determined that the nearest airport to accommodate the aircraft was the Sioux Gateway Airport (in Sioux City, Iowa).[170]

While on final approach to the municipal airport, the right wing of the aircraft suddenly dipped and struck the ground, the aircraft nosed in and rolled over. It broke into three large parts. Of the 296 people on board, 111 died. Most fatalities were among the passengers in the first-class section and in the rear of the aircraft.[171]

2.16.1 Impact of the Crash

Sioux Gateway Airport is a "joint use" airport utilized by civilians and the Iowa Air National Guard, ...aircraft rescue and fire fighting (ARFF) services for the airport are provided by the National Guard.

The Sioux Gateway Airport developed an Airport Emergency Plan (AEP) which was approved by the Federal Aviation Administration (FAA). The AEP is contained in the FAA Airport Certification manual...and contains information such as agencies involved in emergency response, ARFF response, communications, medical assistance, security, and training.

As defined by the plan, an aircraft that is known or suspected to have an operational defect affecting normal flight operations to the extent that there is danger of an accident is an Alert II - Full Emergency. The airport fire chief received an Alert II at approximately 3:25 p.m. Further, when area hospitals and other agencies involved in

> the AEP received the Alert II, they began preparations similar to those made during a 1987 airplane crash drill held at the Sioux Gateway Airport.
>
> The chief responded with (four fire fighting apparatus and a rescue vehicle). In addition, according to the plan, two engine companies from the Sioux City Fire Department (SCFD) and one ambulance from the Siouxland Health Service responded to their pre-assigned stand-by positions on the airport proper. Approximately seven minutes prior to (the estimated time of arrival), information was received that Runway 31 would be used for the emergency landing.[172]

In all, there were 40 to 50 firefighters and as many as 50 volunteers and other rescue workers involved in the initial response.[173] Just prior to the final landing approach by the stricken DC-10, further word was received that, because of the control problems that the aircrew was experiencing, the assigned runway had been changed to Runway 22, one that had been abandoned for use and had fallen into a state of partial disrepair. When the airplane crashed during its attempted landing, there was an immediate flash fire along with the breakup of the airframe. The center fuselage section, containing most of the survivors, inverted and plowed into a cornfield on airport property between the runways.

> Firefighters said that the passengers had about three minutes to escape the intense post-crash fire, which they estimated reached 1,800 F in the main cabin area. The fire was largely suppressed within 45 minutes, but continued to burn for about two hours before being totally extinguished.
>
> Firefighters were amazed as they approached the wreckage to see people stand up and walk away from the aircraft. The aircraft had broken up into several pieces, making it easier for the survivors to exit through openings in the fuselage. Rescue workers managed to transport all of the critically injured passengers to two nearby hospitals within 45 minutes. The hospitals reported

receiving 196 people, of which the majority were treated and released. Of those admitted for treatment, 10 later died of their injuries.[174]

2.16.2 Helicopter Involvement

It's an amazing testimony to the helicopter's value. Within 20 seconds (that's right seconds!) of the July 19 crash of United Airlines' Flight 232 at the Sioux City, Iowa, airport, Marian Air Care's BK-117A-1 was on the scene, preparing its first patient for transport. And, according to a Marian Air Care spokesman, within 30 minutes of the crash, all of the critically injured passengers aboard the ill-fated flight had been transported to area hospitals.

In all, 13 helicopters responded to the disaster, including four hospital-based EMS ships, eight Iowa National Guard Bell UH-1s, and a locally owned utility helicopter that flew over the United wreckage, helping ground units locate victims (in the tall corn). In addition to the Marian Air Care ship, the EMS helicopters included two other BK-117s - one from Life Flight at St. Joseph Hospital in Omaha, Neb., and one from Sky Med at the University of Nebraska Medical Center, also in Omaha, -- and one Intensive Air MBB BO-105 from Sioux Valley Hospital, Sioux Valley, S.D.

Thanks in part to Marian Air Care's rapid response, the two Omaha aircraft arrived too late to assist with patient transports. However, Intensive Air's ship carried two patients from the burning wreckage to an area hospital. Marian's pilot made three trips to and from the crash site, carrying five patients in all to the Marian Health Center in Sioux City.[175]

As part of the investigation of the cause of the accident, it was necessary to locate parts of the failed engine of the DC-10 that had been thrown from the aircraft in flight. This posed a

difficult problem in that the countryside under the flight path was largely rural and heavily cultivated with corn which, at that time of year, was tall and dense in the fields. A computer-aided analysis, based on an estimate of the aircraft's position when the failure occurred, local air currents and ballistics, narrowed the area for the search of engine parts to a 16 square mile section of Buena Vista County, northeast of Sioux City. Along with Nebraska Air National Guard reconnaissance aircraft using infrared photography and other sophisticated search techniques, Iowa Army National Guard helicopter units from Boone and Waterloo aided in the search and in the transport of search parties.

2.16.3 Summary

> In Sioux City, the success in rescuing, treating, and transporting the 186 survivors of Flight 232 can be credited to Woodbury County Disaster and Emergency Service preparedness. Woodbury holds annual disaster drills using different scenarios, one of which is an airline crash. The service involves 22 response organizations including the Sioux City Fire Department. Their presence was felt during the disaster.[176]
>
> Local disaster preparedness officials cited the availability of rescue workers and a long-standing disaster plan as key factors in helping to achieve a high survival rate among the seriously injured. Firefighters also helped extricate people from the wreckage. A forklift was used to lift the tangled wreckage of the cockpit area, which trapped the four pilots until it was moved. All four pilots, including an off-duty captain who came forward to assist the crew from the jump seat, survived.
>
> The airport's disaster plan tapped the resources of Iowa and two neighboring states, Nebraska and South Dakota. The rescue effort drew on equipment and personnel from 25 communities in the farming region around Sioux City. The airport firefighting forces had teamed up with local firefighters and other rescue organizations two years (previously) to conduct a disaster

preparedness exercise. The scenario had called for 100 casualties to be evacuated from the Sioux Gateway Airport from the same spot where the DC-10 (actually) crashed.

Randall S. Curtis, the director of aviation at Sioux City, said another factor that helped to improve the survival rate is that the airport has more crash fire equipment than most facilities its size. The reason for this is that the civilian airport is collocated with an Iowa Air National Guard unit, the 185th Tactical Fighter Group. The firefighting department is a joint-use operation. All the firefighters are members of the Air National Guard.

Curtis reported that several airport authorities from around the U.S. sent personnel to Sioux City to assist in dealing with the disaster. These included representatives from the Massachusetts Port Authority (MassPort), which operates Boston's Logan Airport, and from Dallas/Fort Worth International, Orlando International, and Minneapolis-St. Paul International Airports, among others. In many cases, the representatives handled disaster preparedness at their own airports and were interested in improving their disaster plans based on the lessons learned in the Sioux City situation.[177]

Insofar as the use of helicopters in dealing with the airliner crash in Sioux City is concerned, there was a valuable lesson to be learned. As is evident in the passages above, realistic drills are critical to ultimate success. Drills, from full scale staged mock disasters to "table-top" paper exercises, test the response capabilities of local helicopter assets, and thereby expose problems and difficulties that are otherwise difficult to perceive. The success of rotorcraft at Sioux City has been directly attributed to the drills that are conducted regularly in the area.

That is not to say that there were no problems with the helicopters at Sioux Gateway Airport that afternoon, however. Careful post-incident analysis is also a useful tool in the

assessment of actual response capabilities and subsequent improvement of preparedness plans. There are certain aspects of a real disaster, from the emotional effect the casualties have on their rescuers to the amount and variety of debris generated by the event, that simply cannot be recreated in a drill. Also, small details that go unthought of in the planning of a drill scenario can manifest themselves as major problems in real situations.

Drills, however, help reduce the severity of the impact of these unexpected difficulties. That is the lesson to be learned in this case study. The overall response to the airliner crash at Sioux City, and specifically the involvement of helicopters in that effort, is an example of how the development of well-thought-out disaster preparedness plans, combined with realistic and rigorous testing of those plans with drills, can save lives and yield positive results when the need arises.

2.17 USAIR BOEING 737 CRASH, LAGUARDIA, NY, SEP. 1989

> On September 20, 1989, at approximately 23:22 EDT, a Boeing 737-400 operated by USAir as Flight 5050 overran the end of the runway during a rejected takeoff at LaGuardia Airport, Flushing, NY. Flight 5050 was operating as an "extra section" from New York to Charlotte, NC with six crewmembers and 57 passengers. The aircraft came to rest with the nose wedged atop a landing light trestle, and with the fuselage broken into three sections and partially submerged in the East River. Fatal injuries were received by two passengers.[178]

2.17.1 Impact of the Crash

It appears from preliminary reports that several mistakes were made by the flight crew prior to taking off. The crew realized they were going to abort the takeoff and started to decelerate the plane. The plane ran out of runway, through the overrun area, off the concrete deck, and dropped onto the wooden, approach-light pier. The pier collapsed, the airplane split into three sections and dropped into the water. The two fatalities occurred where the aircraft split at the tail section. All other passengers and crew were rescued from the aircraft.

The crash scene was described as confused by rescuers. Most of the training the fire and rescue crews had received consisted of how to deal with land-based aircraft disasters. The first rescuers on the scene dropped rubber rafts into the water. However, the barnacle covered pilings punctured the rafts causing them to sink.[179]

Units responding to the crash included the Port Authority of New York and New Jersey police department; New York City emergency units and patrol boats; airport police; airport rescue units; and the USCG. The airport's FAA-approved rescue plans call for the USCG to make water rescues. But USCG officials said they learned of the crash 25 minutes after the plane went off the end of the runway..[180] They said they heard about the crash from a New York City police officer who happened to be visiting the station.[181]

2.17.2 Helicopter Involvement

A helicopter was used to rescue only one individual - the first officer Constantine Kleissas. He was pulled from the water by a USCG HH-65 helicopter and taken to airport police headquarters.[182] A USCG HH-3 equipped with a forward looking infrared (FLIR) detector arrived from Cape Cod, Massachusetts to look for victims in the East River.[183] The search was called off when officials realized that the last missing person was the airliner captain who had earlier left the scene.[184]

2.17.3 Summary

Helicopters certainly assisted in this rescue effort, but not to the same magnitude as in other incidents. They were useful in searching for potential victims, illuminating the scene, and rescuing people or portions of the aircraft from the water. A hard-sided raft would probably have been of greater value in this incident. In spite of the delay in being notified of the accident, the USCG was still able to contribute to rescue activities by retrieving the crew member and separately searching the river for other victims.

2.18 EARTHQUAKE, SAN FRANCISCO, CA, OCT. 1989

> At 5:04 p.m., Tuesday, October 17, California's Bay area shuddered through a deadly 7.1 magnitude earthquake lasting 15 seconds. Buildings shook, fires ignited, roads buckled, gas mains broke, and walls

> toppled. A double-decked portion of the Bay Bridge collapsed, crushing the cars of rush-hour commuters below. More than a million people lost electrical power, and many feared that, more importantly, they had lost loved ones as well. A frantic search began for survivors.[185]

2.18.1 Impact of the Quake

The earthquake caused extensive damage in some areas and moderate damage in other areas. Most notably was the collapse of the Nimitz freeway or Interstate 880 on the east side of the Bay. The 880 freeway in some portions is a double decked roadway system. The quake caused structural collapse of the pillars of the freeway causing the top section to fall on the lower section and the lower section then to collapse all the way to the ground. Many people were trapped in this section of the collapsed freeway.

Two other major areas of damage received a lot of attention. The first was in the Marina district of downtown San Francisco. Many of the older homes collapsed, gas lines ruptured, and a fire consumed some of the damaged buildings. The other region of damage was southeast of San Francisco nearer the epicenter of the earthquake. The communities of Santa Cruz and the homes in the rural areas suffered extensive damage. Homes were shaken off their foundations, community buildings collapsed, and utilities were disrupted for days. Earth and mud slides closed highways or restricted traffic to one direction only.

2.18.2 Helicopter Involvement

California as a whole is populated with helicopters. In response to the disaster, helicopter units supported rescue and transport missions after arriving in the Bay Area from as far away as San Diego. The responses of commercial, civil, and military helicopter operators to this disaster is documented in Tables 7, 8, and 9, respectively.

2.18.3 Summary

Helicopter operators suffered many of the same problems the rest of the community did as a result of the quake. Power was knocked out in many areas. Emergency, gas-powered generators were started up to provide power to the gas pumps so helicopters could refuel. On many of their missions the pilots did not have

the normal lighted landmarks of the cities to provide reference points. Entire cities were blacked out. Communications were disrupted throughout the area. Many microwave relay and communication towers were knocked down or out of alignment because of the quake. Phone lines were inoperative or overloaded. Emergency communications were nonexistent or slowed to a crawl. Emergency dispatchers, at times, had to try their calls a dozen times or more before getting through.

Sgt. Tim Miller, Aerial Supervisor, Golden Gate Division, CHP, stated in a phone interview that the CHP helicopters carry three Wolfsburg radios which can communicate on over 24,000 frequencies. This enables the CHP to communicate with virtually every emergency response agency in the San Francisco Bay area. The helicopters were assigned their missions from the emergency command center in Sacramento.

TABLE 7 COMMERCIAL OPERATORS RESPONSE TO THE CALIFORNIA EARTHQUAKE

Date	Operator	Helicopter Type	Mission
10/17	Aris Helicopter, Ltd.	Unknown	check dams, resevoirs, pipelines for damage
10/17	California Shock/Trauma	AS-355 Twinstar	EMS Transport; several Air Rescue (CALSTAR) interhospital transfers
10/17	LifeFlight	MBB BK-117	5 victims transported from Santa Cruz to Bay area
10/17	Larsen Helicopters	McDonnell Douglas	Bay Area Rapid Transit (BART) commuter rail track inspection
10/17	Astrocopters Ltd.	mostly Bell 206B 8 aircraft operated	3 for ENG; BART rail inspection; Pacific Gas & Electric (PG&E), Chevron Oil Co. support; shuttle cellular phones into Santa Cruz
after 10/17	Port of San Francisco	None	opened heliport at piers 30-32
after 10/17	Helicopter Unlimited Helicopter Adventures	Unknown	commuter service to airports or locations across the bay
after 10/17	Aris Helicopters, Ltd.	15 flown including: MD 500E, Bell 206, Schweizer 300, Sikorsky S-58T	Police support; utility crew transport to Microwave repair towers; UPS and FedEx package service; water tank replacement; government official overflights and inspections
after 10/17	Era Aviation, Inc.	Bell 212, 206B	plot devastated areas for California Department of Forestry

TABLE 8 CIVIL OPERATORS RESPONSE TO THE CALIFORNIA EARTHQUAKE

Date	Operator	Helicopter Type	Mission
after 10/17	California Division of Forestry	Unknown	rescue work
after 10/17	Los Angeles Fire Dept.	Unknown	rescue work
10/17	California Highway	Bell 206, Long-Ranger, AS-350B, MD 500D	coordinate communications; transfer personnel; assess damage; 140 hours in 10 days; transport government officials
after 10/17	Digital Equipment Corp.	Unknown	donated funds to cover helicopter time for Santa Cruz & Santa Clara Police

TABLE 9 MILITARY OPERATORS RESPONSE TO THE CALIFORNIA EARTHQUAKE

Date	Operator	Helicopter No	Helicopter Type	Mission
10/17	USCG	UK	Sikorsky HH-3F	bridge and water rescue; evacuate victims from bridge
10/18	US Navy	UK	Sikorsky MH-53E	airlift heavy construction equipment; 200 tons of supplies
after 10/17	US Navy for 12 days	1 2	CH-53 CH-46	arrived from San Diego with 200 tons of supplies
10/17	US Army	6	UH-1	Military Assistance to Safety and Traffic (MAST) transport victims and blood
after 10/17	US Marine Corps	1	CH-46	attempt to remove bent flag pole from top of Ferry building
after 10/17	US Army Reserve Army National Guard USAF Reserve CA Air National Guard	UK UK	UH-1 Others	civilian rescue, resupply, inspection and damage assessment
10/17	Nevada Air National Guard	UK	CH-54	placed on alert, not called
after 10/17	USCG	2 2	HH-65 HH-3F	looking for oil spills; transport dog handlers and dogs; transport FHA Administrator; support President Bush and Vice President Quayle overflights

UK = Unknown

3.0 CONCLUSIONS

3.1 LESSONS LEARNED

The case histories presented in the previous section offer lessons to be learned in the employment of helicopters in disaster response situations. There are examples of how good planning and drill can achieve correspondingly good results in providing needed emergency services. Other instances illustrate how, given a favorable operational environment with good weather, equipment, communications, cooperation, and facilities, local helicopter resources can be brought in at more-or-less a moments notice and work together quite well. We have also seen, as in the case of the Air Florida crash in Washington, D.C., that they can still be extremely effective in spite of a lack of prior planning, not to mention a lack of good weather, equipment, communications, and facilities Finally, some of the case studies bring to light the mistakes, misapplication, errors and omissions that occurred in planning for, and the actual use of, helicopters in disaster relief.

In the 18 case histories presented in this report, rotorcraft transported approximately 3,357 people or an average of 186 people per incident. Of the people transported, it is estimated that 187 lives were saved or approximately 5 percent of the transported population owe their lives to the specialized care which the rotorcraft brought to the scene. A tabulation of each case history with respect to the approximate number of people transported and estimated lives saved is provided in table 10.

On the theory that much can be learned not only from our successes but also from our mistakes, this subsection presents a condensed review of the salient points of helicopter involvement in each case history. It includes, where appropriate, a look at those elements of the operating environment that worked either for or against the successful employment of helicopters in coping with the disaster at hand.

3.1.1 Northeast Blizzards of Feb. 1978

- Almost all forms of transportation along a large section of the East Coast were immobilized, including airplanes, trains, buses, and cars (except four-wheel drive). Snowmobiles and helicopters were just about the only means of getting around.

TABLE 10
ESTIMATED NUMBER OF PEOPLE TRANSPORTED AND LIVES SAVED FOR 18 CASE HISTORIES STUDIED

DATE	INCIDENT	PEOPLE TRANSPORTED	LIVES SAVED
Feb. 1978	Northeast Blizzards Massachusetts, Connecticut, Rhode Island	8	2
Nov. 1980	MGM Grand Hotel Fire Las Vegas, Nevada	522	Unknown
Feb. 1981	Hilton Hotel Fire Las Vegas, Nevada	36	Unknown
Jun. 1981	Tour Bus Crash Denali National Park, Alaska	6	Unknown
Jan. 1982	Air Florida Boeing 737 Crash Washington, District of Columbia	5	5
Jun. 1984	Tornado Barneveld, Wisconsin	0	0
Jul. 1984	Amtrak Derailment Williston, Vermont	5	5
Jul. 1984	Mass Casualty Incident San Ysidro, California	2	1
Jan. 1985	Molten Sulfur Spill Benicia, California	0	0
Aug. 1985	Monocacy River Bus Crash Frederick County, Maryland	1	Unknown
Feb. 1986	Northern California Floods Guernville and Linda, California	2,400	59
Dec. 1986	DuPont Plaza Hotel Fire San Juan, Puerto Rico	236	Unknown
Jan. 1987	Amtrak/Conrail Crash Chase, Maryland	27	27
Oct. 1987	Military A-7D Crash into Ramada Inn Indianapolis, Indiana	1	0
May 1988	High Rise Fire Los Angeles, California	19	2
Jul. 1989	United Airlines DC-10 Crash Sioux City, Iowa	9	7
Sep. 1989	USAir Boeing 737 Crash LaGuardia, NY	1	0
Oct. 1989	Earthquake San Francisco, California	79	79
		3,357	187

- Parking lots at hospitals were used as helipads (in 1978 few hospitals had established helicopter facilities). Security guards were necessary to keep people from parking in the lots.

- The extensive use of helicopters was limited by the availability of suitable and safe landing zones.

- Coordination for ARNG helicopters was handled by state-run emergency operations centers.

3.1.2 MGM Grand Hotel Fire, Las Vegas, NV, Nov. 1980

- Good weather in daylight conditions facilitated helicopter involvement.

- Extra heavy lift helicopters happened to be on temporary assignment at nearby Nellis Air Force Base and were available for use that day.

- No disaster plan was in place in Las Vegas.
  - Police had loose guidelines for control of access (including by air) to an incident scene.

- Las Vegas police felt that it was impossible to write a standard operating procedure (SOP) with sufficient flexiblility to cover all situations.
  - There is an SOP for EMS for single-victim cases.
  - The entire operation was established and coordinated on the scene and in real time by the Las Vegas Metro Police.
  - There would have been no way to anticipate the availability of the additional helicopter assets from Nellis AFB in a fixed plan. The USAF helicopters accounted for 45 percent of all the aircraft used in the relief effort and 100 percent of those employed in balcony rescues.

- Crowd control measures both on the rooftop and on the ground were nonexistent.
  - A single-piloted Metro Police helicopter on routine patrol was the first to spot the fire and give the alarm. It initially landed on the roof to start evacuation and was mobbed. The lack of crowd control created a dangerous situation for both the helicopter and the victims.

- Another dangerous situation occurred when the helicopter landed at an improvised landing zone with no ground or medical support to help passengers exit the aircraft.
- As more helicopters arrived to help, the police helicopter went into high orbit over the scene to serve as a command and control (C&C) aircraft. To do so, it worked jointly with McCarren Airport Approach Control and did an excellent job.

o As the evacuation process grew in a racetrack pattern between the rooftop and the ground, one helicopter hovered nearby at roof level to blow smoke away.

o Helicopters ferried in needed gear from as far away as 55 miles and were also used to resupply fresh SCBA air bottles to the scene, to airlift firemen and equipment to the roof, to evacuate exhausted and injured firemen from the roof, and to remove bodies after the fire was controlled.

o Helicopter related problems cited in the NTSB investigation include:
- rotor noise hampered use of individual firefighter's radios,
- rotorwash blew around debris on the ground (even from 23 stories up) and blankets from the triage area,
- rotorwash fanned the flames and created dust storms when the helicopters landed in landing zones located in adjacent desert areas, and
- balcony rescue operations presented too much safety risk to the aircraft, bystanders and victims and could have killed more than they saved.

o NTSB recommendations:
- keep large helicopters away from the building as much as possible,
- establish landing zones in grassy or paved sites only, away from triage and fire attack areas, and
- train fire and rescue personnel to shield their microphones when using radios near operating rotorcraft.

o CFR trucks were dispatched to the landing zone, to stand by in the event of a crash of a helicopter on landing. Fuel trucks were also sent to the landing zone to

provide on-site refueling capability in order to enhance operational efficiency.

3.1.3 Hilton Hotel Fire, Las Vegas, NV, Feb. 1981

- Only 36 people needed to be evacuated from the roof, many less than the previous MGM Grand Hotel fire.
- USAF UH-1s were effective in blowing smoke from stairwells.
- Once again, as in the MGM Grand Hotel fire, the impromptu command and control system set up by the Metro Police for helicopter operations was effective in assuring a smooth flow of helicopter traffic to and from the rooftop.

3.1.4 Tour Bus Crash, Denali National Park, AK, Jun. 1981

- At such a remote accident site, helicopters were necessary, first, as a means for bringing doctors and medical teams to the accident site and, second, for transporting the victims to trauma care centers after triage and stabilization.
- Fortunately, some of the bus passengers were doctors, nurses, and paramedics who were able to attend to the injured. This significantly reduced the level of medical support that may have been needed.

3.1.5 Air Florida Boeing 737 Crash, Washington, DC, Jan. 1982

- There was no prepared plan for multi-casualty situations in the Washington D.C. area for EMS and hospital personnel to follow and, therefore, no drills had been staged to test preparedness and to identify problem areas.
- Federal and municipal agencies were using their own standard communications frequencies which were not compatible with the fire and rescue or EMS organizations on the scene.
- Command and control functions were carried out well through an impromptu system set up and run by the helicopter pilots who were involved with the rescue and patient transport operations.

- The pilots were able to assess the requirements of the situation and keep the number of helicopters involved to the minimum necessary, thus reducing the risk of secondary accidents in the extremely adverse weather.

o The helicopter proved to be the sole means for rescuing the survivors of the crash in the icy river and the best way to search for other victims on or under the ice.
  - Due to the short distances involved, and the bad weather, surface transport of patients to area hospitals was more effective than by helicopter.

o The need to resolve several problems with search and rescue equipment and aircraft configuration was brought to light in the post incident analysis.
  - Had rescue baskets ("Billy Pugh" nets) and heat-detecting infrared sensors been available, rescue efforts might have gone faster, and perhaps the "sixth man" might have been saved.
  - The skid-type undercarriage on Eagle I was useful in the rescue operations, serving as a platform for the crewman to stand on while lifting the victims from the water; however, the swinging rear doors that were on the helicopter greatly hampered his efforts. Sliding doors that can be locked open in place would have been better.

3.1.6 Tornado, Barneveld, WI, Jun. 1984

o The large number of circling ENG helicopters from TV stations in the area caused some concern on the part of relief workers on the ground. Not knowing much about visual flight rules (VFR) and the "see and avoid" operational concept, many of them expressed a fear that they might have a mid-air collision over the disaster site, thus adding to their problems.

o The uncertainty of the weather conditions following the tornado threatened the safety and limited the usefulness of aircraft in the vicinity of Barneveld. Officials, therefore, did not call in helicopters to assist in relief operations.

3.1.7 Amtrak Derailment, Williston, VT, Jul. 1984

o The timely participation of Vermont National Guard helicopters in disaster relief operations was due in

part to efficient state-wide communications and quick action by the governor.

- In spite of very tight clearances at the temporary landing zones set up in the heavily wooded terrain near the wreck site, the helicopters were able to take off and land safely throughout the operation.

- The use of helicopters produced little or no reduction in patient transport time over ground-based means because of the relatively close proximity of area hospitals and the lack of on-campus hospital heliports. This often necessitated an additional ground transport link (usually an ambulance) from remote landing sites to the emergency room entrances.

3.1.8 Mass Casualty Incident, San Ysidro, CA, Jul. 1984

- Helicopters were used to bring in medical teams to set up triage and give first aid, treat the wounded and to prepare them for transport. Some of the victims were then transported by helicopter.

- The presence of helicopters on the scene had a positive psychological effect on the victims, relief workers, and bystanders. The victims and hostages perceived them as being helpful and most of them reported that their hopes of rescue, and thus their spirits, were raised when they heard helicopters overhead.

3.1.9 Molten Sulfur Spill, Benicia, CA, Jan. 1985

- There was minimal official use of helicopters in support of the fire fighting and life saving effort at this incident due to low ceilings and visibility.

- There were several ENG helicopters circling the scene and hovering nearby, causing difficulty and concern on the part of the firefighters.
  - Rotor noise made it difficult to issue commands to the firefighters, even using radios.
  - Rotorwash had an adverse effect on the thermal balance of the fire. It also diminished the accuracy of predicting the dispersion pattern of any toxic fumes and smoke generated by the fire.

- The incident pointed out the need for, and was the catalyst for the eventual cooperative establishment of, a joint use (police, fire, EMS, etc.) heliport located near the refinery that is available for any emergency situation.

3.1.10 Monocacy River Bus Crash, Fredrick County, MD, Aug. 1985

- Bad weather, which was a contributing factor in the bus crash itself, inhibited the full employment of helicopters in this situation.

- In disaster preparedness planning, helicopters should be considered as an alternate means of patient transport. When the disaster in question is either the result of, or directly related to the adverse effects of, bad weather, helicopters ability to fly safely at that time may be severely constrained. Ground vehicles are often the best primary mode of transport, and helicopters should be used only as a means to augment or enhance rapid response capability when possible.

3.1.11 Northern California Floods, Feb. 1986

- The terrain and flooding made the use of helicopters necessary because debris caught up in the rapidly flowing water prohibited the use of rescue boats. The steep, wooded canyon sides also made escape by land very difficult.

- In the relief effort, a large and diverse fleet of civil, public-service, and military helicopters airlifted approximately 2,400 flood victims to safety.
  - command and control services were well coordinated by a joint Army and Air Force command center established at a nearby airport.
  - Air Force C-130 transport aircraft orbiting overhead assured communications links with rescue helicopters at all times.

- For night rescue operations, two helicopters were sent. One hovered high overhead illuminating the area with its search light while the other would make the pickup.

3.1.12 Dupont Plaza Hotel Fire, San Juan, PR, Dec. 1986

- The high rise hotel building had no emergency landing pad on its roof or even a clear area large enough to accommodate a small helicopter.

- Eventually, the fire vented outside the building. Rising smoke and heat created air turbulence at roof level and added to control and visibility problems for the helicopters.

- The hoists and rescue nets employed by the Navy and Coast Guard helicopter crews, who are trained in their use and practice with them almost daily, were very effective in the rescue operations.
  - The National Guard helicopters were also effective for command and control and air traffic control from high orbiting positions.

- A policeman stationed on the rooftop kept good order and helped prevent panic among the guests as they were being evacuated.

- Heavy helicopters, landing with evacuees at landing zones only 75 feet from the building, fanned the flames and blew smoke towards the firefighters. Their rotor noise also interfered with firefighter communications.

- There was no emergency evacuation plan in place for either the hotel or the local fire department, and no drills had ever been conducted.

- Upon learning of the fire at the hotel, FAA air controllers at the local airport, on their own initiative, requested helicopters to help at the scene. One civil helicopter owner/operator responded and was the first to land on the roof.

- Helicopters were not used to airlift firefighters or equipment to the roof.

- The helicopter evacuation of hotel guests from the roof continued after the fire was reported to be under control, thus risking lives and aircraft needlessly.

3.1.13 Amtrak/Conrail Crash, Chase, MD, Jan. 1987

- Priority three (minor) injuries were transported in military helicopters while the more serious Priority one and two injuries were flown out in civil EMS helicopters that were better equipped to support the victims enroute to the hospital.

- The FAA was contacted by the MSP to establish temporary restricted airspace around the accident scene. The FAA, in turn, assigned the MSP to control air traffic into the area. This step was very effective in reducing the number of non-essential helicopters and other aircraft orbiting the area.

- The military aircraft were hampered by a lack of radio compatibility with the MSP EMS helicopters, SYSCOM and the various fire departments in the area.

- As the initial landing zone became congested, operations were relocated to a larger one nearby.
  - The local fire department controlled the landing zones and provided CFR trucks and medical support.
  - SYSCOM coordinated aircraft movements at the landing zones and provided communications between the crash site Incident Commander, the landing zones, and the hospitals.
  - Cellular telephones were used throughout the system with great success.

- MSP helicopters not being utilized in the relief effort were redistributed around the state and placed on stand-by to provide EMS coverage as needed.

- Maryland's state-wide disaster response plan had been established and tested by conducting several realistic drills. Consequently, the relief operations connected with this accident were extremely effective.

- Problems encountered:
  - the military command post set up for command and control purposes could only communicate with the military machines involved, and
  - civil authorities were unfamiliar with the flight characteristics and the dimensions of the military helicopters and consequently had difficulty accommodating them at the landing areas.

3.1.14 Military A-7D Crash, Ramada Inn, Indianapolis, IN, Oct. 1987

- An landing zone was set up near the hotel for the civil ENG helicopters, while National Guard machines stood by at the airport in case they were needed at the scene.

- A National Guard helicopter was used as a platform to video tape and photograph the firefighting effort to provide an accurate record of what happened as a result of the crash of the A-7D.

3.1.15 High Rise Fire, Los Angeles, CA, May 1988

- The fire was first spotted by Los Angeles Police Department (LAPD) helicopters on routine night patrol.
  - Six maintenance workers were immediately picked up from the roof by the police helicopters.

- The Los Angeles Fire Department (LAFD) used helicopters in several effective applications to deal with this high rise fire.
  - The command and control ship, using its searchlight, searched the building floor by floor for trapped occupants. There would have been virtually no other way to accomplish this critical task as quickly or safely.
  - Firefighters and their equipment were airlifted to the top of the 62-story building to attack the fire from above.
  - A large helicopter was stationed on the roof, at flight idle, as an emergency escape means for the firefighters in the building.
  - A fully equipped EMS helicopter was kept standing by near the scene of the fire in case it was needed.

- Lessons learned by the LAFD in their post-incident analysis include:
  - air operations and the medical group should report directly to the Incident Commander,
  - the air operations and medical groups should use discrete radio frequencies that do not interfere with the firefighters tactical nets,
  - the air operations group should not be demobilized prematurely, and

- helicopters should be kept at least 250 feet away from the fire floor(s) in order to prevent problems with their rotorwash and noise.

3.1.16 United Airlines DC-10 Crash, Sioux City, IA, Jul. 1989

- o There was a good airport emergency plan (AEP) in the airport certification manual. It had been tested successfully by a fully staged drill within the previous 2 years. This AEP has several good features:
  - pre-assigned hovering stand-by spots for local EMS helicopters within the airport boundary,
  - a well defined system of "alert" levels that allows all responders, including area hospitals, to know what to expect and how to prepare for it, and
  - the plan also includes information on the various agencies responding to an emergency, fire and rescue requirements and responsibilities; communications; medical support; security; and training.

- o Helicopters were on the scene of the crash within 20 seconds and had transported all critically injured crash victims within 30 minutes.

- o Helicopters helped ground rescue units locate victims in the tall corn. In so doing, however, their rotorwash caused a problem by blowing around crash debris and blankets from the triage area.

- o National Guard helicopters assisted the NTSB in searching the large rural area for the engine parts from the airliner that were lost in flight. These parts were critical to the investigation of the engine failure that eventually lead to the crash.

- o Other airport authorities from around the country sent representatives to study the Sioux Gateway Airport's emergency response plan in order to learn ways to improve their own plans.

3.1.17 USAir Boeing 737 Crash, LaGuardia, NY, Sep. 1989

- o The firefighting plan at LaGuardia Airport was not prepared for water rescues in spite of the fact that there is water on three sides of the airport.

- The U.S. Coast Guard (USCG) is responsible for water rescue but was not notified until 25 minutes after the crash (by a casual visitor to their station).

o The USCG helicopters used forward looking infrared (FLIR) to search for victims in the water. (There were none to be found). One victim was hoisted from the wreckage.

o Another USCG helicopter hovered high over the scene and illuminated the rescue operations with its nightsun searchlight.

3.1.18 Earthquake, San Francisco, CA, Oct. 1989

o Helicopters were used in relief operations after the 17 October 1989, earthquake disaster in the San Francisco Bay area in several ways, including :
- support rescue operations,
- check dams, reservoirs, and pipelines for damage,
- provide EMS transport between the scene and the hospital and between hospitals,
- inspect BART tracks for breaks and misalignments,
- shuttle cellular telephones to where they were needed,
- transport essential officials and workers around the affected area,
- support police operations,
- airlift crews to repair microwave communications towers,
- keep UPS and Federal Express package service going,
- replace damaged water tanks,
- fly government officials on overflight inspection trips,
- help coordinate communications,
- perform bridge and water rescues, and evacuate accident victims from the collapsed section of the San Francisco Bay Bridge,
- airlift heavy construction supplies and equipment,
- assist in the removal of a bent flag pole from the Ferry Building,
- look for oil spills, and
- transport trained search dogs and their handlers to collapsed structure sites.

3.2 RECOMMENDATIONS

From the case history analyses, there is strong evidence for the need to develop well thought out, coordinated plans. The disasters reviewed provided valuable lessons on the strengths and weaknesses of helicopter use in real life rescue and relief operations.

The insight thus gained into more efficient means of employing rotorcraft is the basis of the following recommendations that focus on several planning and functional elements: basic planning concepts - hazard analysis and checklist development; inventory of resources; communications - authority and responsibilities; drills and post-incident evaluation; and landing zones.

3.2.1 Basic Planning Concepts

Pre-incident Hazard Analysis - Certain disaster situations and levels of disaster impact can be anticipated in a "conceptual" sense: hurricanes in the Gulf of Mexico, tornados in the Midwest, blizzards in New England and earthquakes on the West Coast are all likely to occur with some regularity. Other disasters require some speculation, e.g. airplane crashes, train derailments, ship-board fires at sea or in port. Plans for response to these tragic events and capability for relief activities can also be developed, and in fact may be mandated by transportation authorities within the various jurisdictions. For example, the FAA's Federal Aviation Regulation (FAR), Part 139 requires a crash/fire rescue plan to be established at an airport in order for it to be approved to support commercial service operations.

The hazard analysis function in disaster planning should consider how, where, and when helicopters can be used to support emergency operations. Damage assessment, rescue, and transport of victims, medical teams, and supplies are part of the support that should be identified according to predetermined response levels based on the degree and scope of damage and injury.

Implementation Checklists - As noted above, the anticipation of disaster gives the controlling agency the ability to create checklists for implementing the plan. Envisioning a particular disaster scenario often suggests, as part of that process, activities and means that may be useful or necessary to cope with it. By including an escalating scale in the scenario, various levels of response are determined and the response requirements

for each are defined. A major component of the checklists thus created are the required resources for aiding the appropriate relief effort. Helicopters are easily included in these checklists by identifying their missions in relationship to the response activity/activities to be performed, where that support can be obtained, and when it can be expected.

3.2.2 Inventory of Resources

Inventory - Before plans can be developed for the use of helicopters within any level of jurisdiction, it is first necessary to know what resources are available. For planning purposes, it is generally difficult, if not impossible, to determine exactly how many and what types of helicopters will be available in a given area at a given time. The larger the area, the more difficult that determination becomes.

A list of potential helicopter resources and points of contact (POC) should be developed. The reliability levels of a given helicopter resource will vary with the specific agency involved and the timing of the disaster, as was demonstrated in the MGM Hotel fire and the train wreck in Vermont. Luck, therefore, will play a part in any situation as well. Accordingly, a general list of all potential helicopter assistance should be maintained and updated frequently.

3.2.3 Communications

Communications - Good communications are essential for the success of any complex operation that requires people to function effectively in uncertain and rapidly changing situations. The nature of those communications depends greatly on the number of people involved, the level of sophistication of their equipment, the distances between them, environmental conditions, and any number of other factors.

Most organizations develop an effective means of communication that suits their needs within their system. Usually that includes a communications interface with other similar organizations and systems. But, as the number of organizations involved in a situation increases and their character becomes more diverse, the likelihood of all of them being able to communicate with each other diminishes significantly.

The key to solving these problems, ironically, is communications conducted calmly before the fact, when all the

parties involved can work out a plan that will meet their needs. The communications plan has to be as comprehensive as possible and yet sufficiently flexible to adapt to changes as they occur in the situation and in the capabilities of the organizations involved. Once the communications plan is developed, it must be given the widest possible dissemination and tested for effectiveness through drills and exercises. If it does not work well then it must be either modified, or the users must be better trained and drilled, or a combination of both must occur.

Radio Communications - There is a common misconception that all aircraft have radios and that they can talk to all other aircraft, as well as anyone on the ground with a radio. While communications ability is improving, aviation has not yet reached that level of sophistication. As is evident in many of these case histories, there is often a communications gap between civil and military aircraft, and between aircraft and ground units. At times this has been due to incompatibility of the radios being used by the various parties. At other times, it has been due to the lack of a common frequency or a common communications protocol. Sometimes, it is due simply to poor techniques in using otherwise serviceable equipment under unusual or adverse circumstances.

Mutual Aid Agreements - Natural disasters frequently overlap several adjoining jurisdictions. Some more concentrated events, like the Air Florida crash in Washington D.C. for example, can occur on or near borders which may confuse the issue of which responding agency is in charge. Of course, large disasters and mass-casualty situations may often exceed the capability of local resources to deal with them alone. Mutual aid agreements are therefore commonly established between contiguous disaster response agencies. As a minimum, these agreements should incorporate protocols for requesting helicopter support, priority of resources and command responsibilities.

Command and Control - The case studies show several instances where helicopters have been very effective in providing disaster relief in spite of a lack of a structured command and control system. This is a testament to the high level of professionalism, experience, and ability of most helicopter pilots involved in this type of work. It is also indicative of the fact that an established, rigid framework for helicopter command and control is not always necessary.

Flexibility is the essence of most helicopter operations. These versatile machines are well suited to this type of

operational concept and the men and women who fly them are, for the most part, accustomed to and comfortable with functioning under such conditions.

The uniqueness of the circumstances associated with each disaster allows no practical way to establish a structured helicopter command and control system that can cover every eventuality. There are simply too many variables. However, the identification of where communications must be extended in order to accomplish required missions will provide a foundation on which to build. Of prime importance is the designation of command authority to an agency and/or individual with an understanding of helicopter requirements and capabilities.

The goal is to provide as favorable an operating environment for helicopters as possible within the constraints of safety, one that allows maximum flexibility and adaptability to a constantly changing situation. Lines of communications should be open constantly keeping information flowing between all involved parties before, during, and after an incident. As a general disaster preparedness philosophy, the establishment of a comprehensive communications system will provide positive command and control services and assure the flexible operating environment that helicopters need to function most effectively.

3.2.4 Drills

No Surprises! - Once a plan, or operational concept, is established and in place, there is no way to tell if it is effective without testing it. Drills must be staged to validate the plan and to instill a level of confidence in it on the part of the community it serves. Drills also bring to the surface any deficiencies in the plan and/or the people and organizations following it, as well as unexpected influences that may reduce its effectiveness. By exercising the plan these problems are identified and, in so doing, the means for resolving them often become apparent.

One of the chief goals of a drill is to eliminate any surprising elements that may be endemic to the plan. It is a way to do this under controlled circumstances, without further risk to the victims of an actual disaster. No drill, however realistic, can fully simulate every aspect of a real disaster. There are always going to be some surprises. But by eliminating as many of them as possible before they can threaten the success of the operation, the negative impact of the ones that may be

left is reduced. This is because responders have more reserve capacity to deal with various new situations as they arise.

As the case studies point out, the regular use of drills, or the absence of them, can have a dramatic influence on the outcome of disaster relief operations. The response to the DC-10 crash at Sioux City is a good case in point. As luck would have it, the actual disaster closely matched the scenario of a drill held in the same location 2 years prior. Consequently, there was very little that surprised the relief workers in that situation. Even without such luck, however, drills of any kind, whether a simple table-top exercise or a fully-staged drill complete with helicopters transporting moulaged (simulated injury) victims, provide the opportunity for people and organizations to work with each other and come to understand their capabilities, requirements, and limitations. Drills are one of the best ways to develop and establish that good operational environment that is necessary for the effective employment of helicopters.

Post-Incident Analysis - As was stated earlier, no drill can fully recreate every aspect of an actual disaster situation. Therefore a careful post-incident review and analysis of real occurrences can yield information that is not obtainable by any other means. This paper is an example of that process. The study of past successes and failures in using helicopters to cope with disaster situations can be as beneficial as conducting drills. An ongoing program combining both drills and post-incident analyses will help assure maximum preparedness.

3.2.5 Landing Areas

Temporary Landing Zones - The chief advantage of a helicopter over all other forms of transportation is its ability to land and take off in an area only a bit bigger than the helicopter itself is. Moreover, the helicopter's ability to hover means that it does not have to land to pick up or discharge cargo and passengers. Hoists and rope ladders can be used to reach people who are otherwise inaccessible. Also, cargo and heavy equipment can be slung externally beneath many helicopters in operations that do not require them to actually touch the ground.

For the most part, however, helicopter pilots prefer to operate from landing zones that are as large as possible in order to assure the widest possible margin of safety. It is always the pilot's ultimate responsibility to decide whether or not to use a given landing zone. There are many factors that influence that

decision, not the least of which is the nature of the situation. In emergencies where lives are at stake, a helicopter pilot may operate in a landing zone that he or she may not otherwise use. Regardless of the urgency, however, safety is always the primary determining factor. There is no sense in risking additional lives needlessly.

With this in mind, disaster planners should incorporate into their plans means for the safe operation of helicopters to and from safe temporary landing zones. The establishment and safe operation of helicopter landing zones should be the specific responsibility of an assigned individual with knowledge of helicopter capabilities and requirements. That individual should be able to communicate with the aircraft, the Incident Commander, landing zone controllers, medical facilities and other destinations, and have the authority to make decisions and issue orders regarding aircraft utilization and safety without prior consultation.

Permanent Helipads/Heliports - It is clearly impossible to establish permanent helicopter landing facilities near all potential disaster sites, even if they were able to be foreseen. It is possible, however, to predict with a fair degree of certainty where the other end of a helicopter trip associated with a disaster will be, and that is at hospitals. Many, if not most, hospitals now have some type of provision for receiving patients via helicopter, whether a full-blown heliport, a cleared parking lot, or a nearby open field. The location and character of the hospital landing area is necessary information for the pilot prior to being dispatched there with patients onboard or to bring back medical teams and supplies. Disaster plans should maintain a complete and comprehensive listing of all available heliports at hospitals in the area of concern and all other public and private use heliports that may serve as a primary or alternate landing site in response to disasters or emergencies.

The potential requirement for emergency access to helicopter landing sites in urban areas is relatively high, given the number and concentration of people, vehicles, and buildings typically found in cities. Officials responsible for disaster preparedness should urge communities to establish public-use heliports, or at least emergency landing areas on high-rise building rooftops, wherever possible. The public-use heliports thus created will also provide the added benefit to the community of commercial and public service use under less critical circumstances.

These findings have been presented in light of the 18 case histories in preceding sections of this document. They will be used to develop a comprehensive set of guidelines for disaster planners to incorporate the use of helicopters into their preparedness plans. Helicopters are extremely useful in disaster response situations, as they have proven in the past. Proper planning can enhance that usefulness and help to maximize the benefits that are derived from the presence of rotorcraft in the community.

ACRONYMS

AEP	- Airport Emergency Plan
ARFF	- Aircraft Rescue Fire Fighting
ARNG	- Army Reserve National Guard
ATC	- Air Traffic Control
ATF	- Bureau of Alcohol, Tobacco, and Firearms
C&C	- Command and Control
CFR	- Crash, Fire and Rescue
CHP	- California Highway Patrol
DOD	- Department of Defense
EMS	- Emergency Medical Services
ENG	- Electronic News Gathering
FAA	- Federal Aviation Administration
FLIR	- Forward Looking Infrared
H-3	- Maryland State Police Helicopter 3
HAZMAT	- Hazardous Material
LAFD	- Los Angeles Fire Department
LAPD	- Los Angeles Police Department
LZ	- Landing Zone
MASSPORT	- Massachusetts Port Authority
METRO	- Metropolitan
MIEMSS	- Maryland Institute for Emergency Medical Services Systems
MSP	- Maryland State Police
NDMS	- National Disaster Medical System
NFPA	- National Fire Protection Association
NG	- National Guard
NOAA	- National Oceanic and Atmospheric Administration
NTSB	- National Transportation Safety Board
NWS	- National Weather Service
PA	- Public Address
PACT	- Police and Citizens Together
POC	- Point of Contact
RT	- Roof Top
SAR	- Search and Rescue
SCBA	- Self Contained Breathing Apparatus
SCFD	- Sioux City Fire Department
SCSD	- Sonoma County Sheriff's Department
SD	- Sheriff Department
SOP	- Standard Operating Procedure
SWAT	- Special Weapons and Tactics
SYSCOM	- Systems Communications
USCG	- United States Coast Guard
VFR	- Visual Flight Rules

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